

PROCEEDINGS OF THE LINNEAN SOCIETY OF LONDON

154th Session (1941-42)

Part 1

CONTENTS

	Page
<i>PROCEEDINGS, 30 OCTOBER 1941</i>	1
<i>Streptocarpus nobilis</i> C. B. Clarke, with cleistogamic flowers. By Sir ARTHUR W. HILL. [Exhibit.]	1
New light on John Ray. By Prof. C. E. RAVEN, D.D.	3
Observations and experiments in Africa by the late C. F. M. Swynnerton on wild birds eating butterflies and the preference shown. By Prof. G. D. HALE CARPENTER	10
<i>PROCEEDINGS, 13 NOVEMBER 1941</i>	46
On the occurrence in Hampshire of a spider of the family Argiopidae probably of foreign origin. By E. A. ROBINS. [Abstract.]	46
The position of the Caytoniales. By Prof. T. M. HARRIS. [Abstract.]	47
Observations on Jacobson's organ and its innervation in <i>Vipera berus</i> . By D'A. BELLAIRES. [Title only.]	48
<i>PROCEEDINGS, 27 NOVEMBER 1941</i>	49
A photographic record of the Linnaean Collections. By J. R. NORMAN, F.L.S.	49
<i>Digitalis purpurea campanulata (monstrosa)</i> . By Mrs. MENIE WATT	57
White flowers in <i>Ranunculus Flammula</i> Linn. By Dr. B. BARNES	58

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PROCEEDINGS OF THE LINNEAN SOCIETY OF LONDON

154th Session (1941-2)

Part 1

PROCEEDINGS OF THE GENERAL MEETING

30 October 1941

Dr. E. S. RUSSELL, O.B.E., M.A., President,
in the Chair

The Proceedings of the General Meeting held on Thursday, 10 July 1941, having been circulated, were taken as read and confirmed.

The President announced that, owing to increased duties as a Commanding Officer of the Home Guard, Major F. C. Stern had expressed the wish that for the duration of the War his work as Treasurer of the Society should be carried on by a Deputy; and invited Dr. B. Barnes, who had agreed to act as Deputy Treasurer, to occupy the Treasurer's seat on the bench.

The thanks of the Society were recorded for gifts made since the last meeting:—From the late Francis Druce, F.L.S. (two bequests), Mr. T. A. Dymes, Prof. A. C. Hardy, Mr. J. Hornell, Mr. Lowell J. Reed, Dr. E. N. Thomas, Prof. F. E. Weiss, Miss Maud Williams, The Pharmaceutical Society of Great Britain, and The Royal College of Surgeons of England.

Certificates of recommendation of the following candidates for Fellowship were read, for the first time, in favour of John Chear, Florence Annie Stanbury, Basil Derek Wragge Morley, Harold Cyril Bibby, Param Nath Bhaduri and William Springthorpe Lacey.

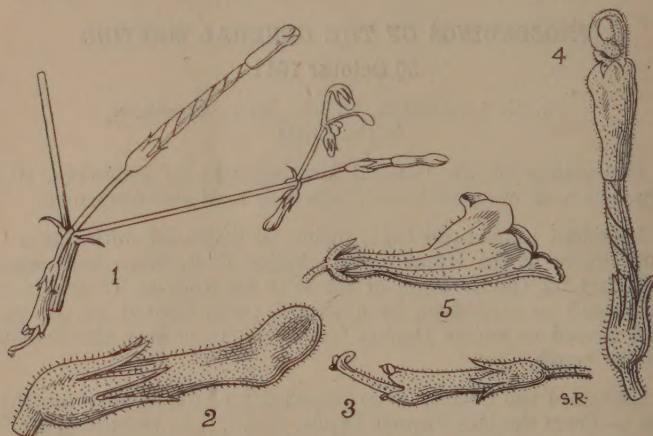
The President reported the deaths of the following members:—Dr. Rose Bracher, Mr. Patrick M. Hall, Mr. M. Alam, Mr. R. J. Flintoff and Mr. C. A. Newman, Fellows of the Society, and the Rev. H. J. Riddelsdell, Associate.

Sir ARTHUR W. HILL, K.C.M.G., F.R.S., exhibited a plant of *Streptocarpus nobilis* C. B. Clarke, with cleistogamic flowers. (Discussed by Mr. I. H. Burkill.)

Abstract.—

The flowering plant exhibited, was grown at the Royal Botanic Gardens, Kew, from seed collected in Nigeria (Toka Rocks, No. 5022), by Captain E. Milne-Redhead. In this species—*S. nobilis*—the inflorescence commonly includes two kinds of flowers: (a) chasmogamous, with quite large corollas which open in the usual way and which are, apparently, soon deciduous; and (b) cleistogamous, with very small corollas which do not open, but which persist as a cap covering the style and stigma and are carried up on the apex of the fruit as the latter develops (figs. 1 & 2).

None of the plants grown at Kew have produced chasmogamous flowers, and most of the flowers were cleistogamous. There were, however, a few in which the corolla had opened and the style was exerted, the corolla being exactly like those of the cleistogamous flowers except that the lobes had separated from one another instead of remaining coherent (figs. 1 and 3). In the ordinary cleistogamous flowers the style



FIGS. 1-5.—*Streptocarpus nobilis*. 1, part of inflorescence, showing cleistogamous flowers, young fruit and a flower with open corolla and exerted style, natural size; 2, young flower, $\times 4$; 3, flower with open corolla and exerted style, $\times 2$; 4, young fruit, with the style just exerted from the corolla, $\times 2$; 5, chasmogamous flower, natural size. Figs. 1-4 from a plant grown at Kew; fig. 5 from specimen in the Kew Herbarium (Mildbraed, 7329).

remains recurved at the apex and the stigma is held against the dehiscing anthers, the unopened corolla fitting very closely over the recurved style and stigma. The pressure exerted by the elongating gynoeceium results in the corolla being pushed off from the receptacle, but it usually remains unopened and tightly sheathing the style and stigma. In one or two flowers, however, the corolla-lobes were found to have been forced apart and the still recurved style had emerged (fig. 4).

Dr. C. E. RAVEN, Master of Christ's College, Cambridge, gave an account of his paper, 'New light on John Ray'. (Discussed by Dr. J. Ramsbottom, O.B.E., Mr. I. H. Burkill, Mr. S. Savage and the President.) [Printed in full below.]

Prof. G. D. HALE CARPENTER, M.B.E., F.L.S., gave an account of his paper, 'Observations and Experiments in Africa of the late C. F. M. Swynnerton on wild Birds eating Butterflies, and the preferences shown'. (Discussed by Dr. L. Richmond Wheeler.) [Printed in full on p. 10.]

NEW LIGHT ON JOHN RAY.

BY CHARLES E. RAVEN, D.D.,
Master of Christ's College, Cambridge.

WHEN a theologian whose only public claim to a place in scientific circles is based upon popular pictures and patter about bird-life is invited to address a great scientific society, he must feel that a personal explanation is inevitable. In my own case, the honour that you have done to me—and which has touched me very deeply—is due to the fact that for the past three years my time and interest have been largely given to the study of the great pioneer of botanical and biological studies, John Ray. The outbreak of war, closing (to some extent) the possibilities of field work—to photograph a bird at present is to turn out half the constabulary and all the Home Guard of the neighbourhood—made the pursuit of flora and fauna by proxy all the more fascinating. To ride in imagination with the great John over the marshland of Teversham, or the chalk of the Gogmagogs, to follow him further afield to Hincklehaugh or Prestholm, to share his excitement over the first discovery of *Trifolium ochroleucum* at Cherryhinton or of *Bartsia alpina* at Orton, or *Bartsia viscosa* at St. Columb, was almost as attractive as to make such expeditions in person. Since then I have read almost every word that survives of his very voluminous writings, and have been concerned to collect from the allusions of the most reticent and modest of men whatever bore upon his life-history or contributions to science. It has been a singularly enjoyable task—partly because he writes delightful Latin, and in that tongue reveals a sense of style which his English never quite equals, but much more because even for an amateur and ill-qualified field-naturalist like myself his clarity of description and flair for selecting points of distinction make the identification of his finds comparatively simple. Remembering that he not only wrote of all the plants known in his time, but produced pioneer work on mammals, birds, reptiles, fishes, insects and fossils, you will appreciate how absorbing was my research.

It is one of the curiosities of the history of Science that 'our countryman the excellent Mr. Ray', as Gilbert White called him, though he was honoured until 100 years ago and still gives his name to at least two learned Societies, should never have received his proper homage and should now be almost entirely unknown. The patron-saint of this Society, the great Linnaeus, who could inscribe one of his portraits with the boast *Deus creavit, Linnaeus disposuit*, is a household word. Yet the 'system' of which he was so proud was artificial and has long since perished, while Ray, whom he drew upon but sedulously slighted, laid the foundations of a true classification both in botany and in zoology, and was a far more profound student of biology and the living organism.

The reasons for our neglect of our greatest naturalist are many. He wrote in Latin—except the Ornithology and the two books of natural philosophy—at a time when Latin was dropping out of use. He was a biologist at a time when the Royal Society, as Walter Moyle said, had 'no room for Natural History; Mathematicks have engrossed all'. He took little interest in nomenclature and gave long descriptive titles to species. Above all, he was the blacksmith's son of Black Notley, who,

having won a fellowship at Trinity and a secure future, surrendered it for conscience' sake in 1662, threw himself 'on Providence and good friends', and spent the last 25 years of his life, old and in pain, in the cottage that he had built for his mother. Incidentally, the output of those years is probably the largest in sheer mass of material that any one man has produced since Aristotle—the 3000 folio pages of the 'Historia Plantarum'; the two editions of the Synopsis or Handbook, which J. E. Smith described as the best national flora ever published; the revised Methodus or Classification of plants which was reached after long correspondence with Rivinus and Tournefort and anticipated that of de Jussieu; the Synopses of Mammals and Reptiles, of Birds and Fishes; the unfinished but fascinating and most laborious History of Insects; the second edition of his English Dialect Words, which Skeat described as the most important contribution to the subject made until his own time; the little manual of devotion, *A Persuasive to a Holy Life*: the many editions of the *Miscellaneous Discourses* and of the *Wisdom of God*—each almost a new book—in which he initiated the scientific study of geological phenomena and of the adaptation of living organisms to their environment. But it was produced in a cottage without the backing of wealth or learned society, without the help of libraries and museums and the comradeship of colleagues. John Nidd at Cambridge, Francis Willughby and Philip Skippon, in his years of travel, Tancred Robinson and Hans Sloane in the last period, gave him splendid friendship: he had a genius for letter-writing: but when he died his friends erected a tomb, but took no other adequate steps to perpetuate his memory.

The fact is that there has never been any proper record of his life. William Derham, a parson with whom he had corresponded, undertook the task which his neighbour Samuel Dale was too modest to assume, and eventually published a volume of *Philosophical Letters*. From these every personal touch and much of the most interesting details have been excised—Derham's own rather limited outlook dictating what should survive. The 'Life,' for which Dale produced a brief but very valuable epitome, but which Derham was to write, was never finished, and though published some forty years after Ray's death, is miserably incomplete and inaccurate. Edwin Lankester, who re-edited the remains for the Ray Society, was entirely uncritical, and in his notes, except for those contributed by Babington, grossly careless. Dr. Boulger, author of the article in the D.N.B., and of several papers, had not the time to do more than summarize some of the existing material and disclose a few additional letters; the clues supplied by Ray's own books he never seems to have followed up. In spite of the excellent service rendered by the late Dr. Gunther in collecting and editing for the Ray Society long series of Ray's letters to Peter Courthope, Martin Lister, John Aubrey and Edward Lhwyd, so little attention was paid to the available data that the Register of Black Notley, which reveals the facts of his family, had never been searched; a legend about 'Squire Wyville' and his youth had been accepted unexamined; the second of his long botanical journeys, which included a visit to the Isle of Man and the first records of *Brassica monensis* and of the Manx Shearwater, as well as of many northern plants, was wholly ignored; and the ascription to Willughby of a major share in his zoological work was allowed to pass unchallenged.

In consequence the great British naturalists of last century knew almost nothing of their greatest predecessor. Huxley never mentions him : Darwin, who revered Linnaeus and Cuvier, and knew Paley's *Natural Theology* almost by heart, never mentions him : neither Bentham nor Hooker seem to have known anything of him : only Babington, founder of the Ray Club, and original member of the Council of the Ray Society, shows any serious interest in his work. Today, if I may judge by my own experience, though Ray's Wagtail and the Ray Society preserve his name, it is for the vast majority even of naturalists, a *nudum nomen*. He of whom Pulteney, not altogether unjustly, claimed that 'without the patronage of an Alexander he became the Aristotle of England and the Linnaeus of his age', has dropped entirely out of knowledge.

It is a pity : for the man was not only great in his quite unique achievements as founder and pioneer of botanical and zoological studies, but great in his influence upon the development of our national character and great in his personal history and quality. It may be well to speak of these latter first.

Of his character it is sufficient to say that no man who knew or knows him has ever found ground for criticism, has, indeed, been able to resist his attractions. Robert Morison, 'a Scot from Aberdeen', a Scot on the make, who had never seen him, wantonly insulted him ; Woodward, the geologist, a cantankerous and abnormal creature, who also had never met him, sneered at him as a scribbler. Otherwise, in all the mass of letters and allusions, from his tutor James Duport at Trinity to his latest eulogist, our own Sir Albert Seward, there is not a word except of admiration. John Aubrey, the gossip ; Robert Hooke, usually so jealous ; John Tillotson, Archbishop of Canterbury ; Samuel Dale, staunch non-conformist ; Philip Skippon, son of Cromwell's major-general ; Sir Robert Barnham, of the Cavalier parliament ; Malpighi and Tentzel, Marchand and Hermann and Hotton, the continental savants ; Peter Dent, the Cambridge apothecary ; Tom Willisel, the tramp botanist—these men loved him. His biographers and disciples in later days have emulated the affection of his contemporaries.

It was this genius for friendship which gave the blacksmith's son in that almost feudal age his unique influence. Alike by his books and by his letters, even when he was too old and ill to attend the Royal Society or visit his wealthy colleagues, he created, stimulated and directed a passion for natural history. Sloane and the British Museum, Lhwyd and the beginnings of geology, Lister, Robinson, Plukenet, Dale, Sherard, Petiver, Moyle, Morton and, in the next century, Pennant and Gilbert White, and a host of others, owed to him their devotion to flora and fauna. If at this time it amazes our French friends that the greatest British dailies should chronicle the arrival of the first swallow or the spread of the Comma butterfly, if an almost religious devotion to nature should be a characteristic of our country, we owe this admirable element in our heritage to John Ray more than to any other man.

But what of Ray as a scientist ? What is the value of his contribution to knowledge ?

His first excellence is only seen if it is realized that when he began his work there was no scientific framework, no line between magic and fact,

no test to distinguish hypothesis from superstition. Henry More, the great Platonist, in his *Antidote against Atheism*, fills the second book with sensible discussions of natural lore, and the third with wild stories of were-wolves and witches, and regards the two as equally valid. Sir Thomas Browne, of the *Religio Medici*, was convinced of the reality of witchcraft. In the year of Ray's *Historia Plantarum*, the Law Reports were filled with dozens of pages of evidence on the criminal correspondence between west-country peasant women and the 'black-boy'. Yet Ray is not only wholly free from any sort of belief in magic; he has no use for astrology or for spiritualism; he will not allow the gryphons and unicorns, the yales and rocs into his zoology; he attacks in his very first publication the doctrine of 'signatures' in botany; he denies the doctrine of spontaneous generation in spite of his observations of Charlock in the Fens; and throughout exhibits an insistence on observation and experiment as rigid as that of Darwin or Huxley. There is a very striking instance of the change which this rejection of folklore involved for him. In the most poignant of all his letters when he reports the death by jaundice of his dearly-loved daughter Mary, he describes how he had gone to the newest and most expert doctor and consulted the great London specialist Hans Sloane in vain; and then, reverting in the bitterness of his bereavement to the old world of his herb-woman mother, cries out that he ought to have treated the child with the remedy that cured him in his youth—stallion's dung soaked in ale! No man did more than Ray to deliver us from that old world of superstition and wizardry from which he himself was sprung.

His second is in his profound appreciation of the importance of structure as determining difference of species. Before him, whether in botany or in zoology, there was no clear idea of specific distinctness. Differences of flower-colour, of size, of doubleness of flower, or of sex were regarded as sufficient to constitute novelty of kind. As a result, species were multiplied intolerably in every field of natural science. Ray from the beginning studied comparative anatomy, and set himself to reduce to order the chaos of his predecessors, identifying their synonyms, and insisting upon permanent and anatomical characters as alone valid. Moreover, he possessed, as a result of his long discipline in Latin, Greek and Hebrew, a power of exact description which Gilbert White in a famous passage declared to be unrivalled. This, as every systematist knows, is a rare and vastly important gift: when combined, as it was in his case, with a flair for fastening upon significant and rejecting trivial characteristics, it amounted to genius. In his work on birds his allowance for phases of plumage and differences of sex is very remarkable: so, in his *History of Fishes*, is his treatment of genera like the Whitefish and the Chars. But the test of his merit is in the *History of Insects*. This consists simply of a mass of unedited and incomplete descriptions, chiefly of Lepidoptera. He was the first to recognize that all stages—larva, pupa and imago—must be studied together if an accurate taxonomy is to be attained; and he left records of the larvæ and/or imagines of some 300 species. Of these practically all can be identified with almost complete certainty, although the notes are unclassified and, of course, accompanied by no figures and no references to other works. (I may perhaps state

that I identified nearly all of them personally before discovering that the industrious Werneburg had done the work already : knowing the Lepidoptera of Essex better than he did, I was able to correct his list in several places !)

Thirdly, from this power of exact description he gained a sound insight into problems of taxonomy. Among the criteria which he laid down for determining a system of classification was the insistence that it serve a practical purpose—that of helping the novice to recognize his finds. Hence he never regards classification as an end in itself : it is a means to knowledge and study of the living organism. Hence, too, he takes the species as a whole and refuses to classify it by one single set of characteristics, paying regard rather to the general structure and fastening upon such differentiating points as seem to him significant. In these two respects he is in sharp contrast with Linnaeus and much closer to modern ideas.

Fourthly, he insisted upon the study of the living organism in its environment—this in contrast with the charge which Morison brought against him of drawing his knowledge from closet work and dried specimens. He travelled as extensively as any botanist—so widely in Britain that he could contribute to Gibson's edition of Camden's 'Britannia' from his own knowledge, lists of the rarer species for every county except Middlesex. He added by his own observation more new records to our flora than any other man. He insisted upon the importance of habit and, in his work on zoology, on behaviour. He had an almost uncanny power for the observation and description of points of real interest. Thus one of his earliest observations in entomology—of an *Ammophila* dragging to its burrow and burying a caterpillar—anticipates Fabre and the *Souvenirs Entomologiques* : and if I may be personal, it came to me as something of a shock to find that two observations of bird behaviour whose significance I thought I had been the first to notice—the continuous laying of eggs by many small birds when the egg is removed daily and the clutch therefore left incomplete, and the sanitary habits of young hawks—had both been duly noted and recorded by Ray in the seventeenth century. His *Wisdom of God in the Works of Creation* contains a mass of such observations—which have, in fact, never yet been fully appreciated by zoologists.

Fifthly, he is singularly free from those theological and traditional prejudices which have so sadly hindered the development of science. There was, of course, no conflict between science and religion in his day—Boyle and Newton, like himself and Grew, were convinced and honest Christians for whom the data of nature and of religion were alike deserving of study. Equally, of course, he shared with his contemporaries certain general ideas as, for example, that creation was rather an act than a process, and that the world was comparatively new—some five thousand years old. These ideas Hobbes, the atheist, held quite as strongly as Newton or Ray : they were part of the climate of the time. Nevertheless, in dealing with physical geography, and especially with fossils—which, unlike almost all his contemporaries, he declared to be of organic origin, genuine remains of plants or molluscs, or fishes—Ray recognizes that the 'novity of the world' is difficult to maintain, and indicates his readiness

to abandon it. So, too, though he does not fully accept evidence drawn from the breeding of primroses and cowslips that species are mutable, he definitely adopts Cudworth's belief in a 'plastic nature' or *élan vital*, a secondary cause by whose operation the continuous and often imperfect processes of development are controlled. In this respect he does not share the point of view of Grew or of Paley, for whom the world is a great machine or clock, which God created and set working; he approximates to a much more dynamic and even evolutionary outlook. Moreover, if his religion does not seriously distort his science, it certainly gives to him a principal source of his greatness—his power to 'see life steadily and see it whole'; to correlate data gathered from the widest possible range of experience; to compare results obtained in one field with those from another; to bring into a single ordered and consistent scheme, a realm of law, all phenomena whatsoever.

In justice to Ray a word must be said as to the light which a full study of his work throws upon his relation with his friend, colleague and patron, Francis Willughby. It will be familiar to many of you that a century ago, when Sir James Smith—a name much honoured in the Linnean Society—made some laudatory and, in fact, thoroughly accurate remarks about Ray, great offence was taken by ornithologists for what seemed a disparagement of their patron-saint, the author or reputed author of the *Ornithology* and the *History of Fishes*. Botanists were plainly told that 'the gentle Ray', though no doubt quite accomplished in the vegetable kingdom, knew nothing about the higher levels of creation, and that if Willughby was not solely responsible for the classification and observations in at least these two books then Derham was a false witness, and Ray, on the evidence of his own words in the Preface to the *Ornithology*, a liar. Even Alfred Newton, who ought to have known better, intimates that though Ray was at first the tutor, Willughby rapidly outstripped him. What are the facts?

When two men have collaborated closely; when as in this case, one of them has been befriended, supported and endowed with funds, and when, in consequence, he does his uttermost to repay the debt of affection and obligation, it is invidious to compare them, and perhaps impossible to draw a hard line between the several parts of their joint work. But this much is clear.

Willughby, when Ray was with him, was enthusiastic: he had an eager and acute mind, great energy, and a gift not always tempered by sound judgment for fastening upon salient points. But even when they were together it was Ray, not Willughby, who made the lists of birds and fishes, recorded the observations, and made the collections. Indeed, on the evidence it seems clear that Willughby was at least as much interested in mathematical, archæological and political problems as in zoology.

On their various journeys, Willughby did not accompany Ray nearly so continuously as has been supposed. Thus, on the long journey round Wales to Cornwall in 1662 he left Ray and Skippon before they reached Bristol. On the continental tour he was only with them for one year: it was Skippon, not Willughby, who accompanied Ray to Sicily and

Malta, who spent the winter with him in Rome, and then toured Switzerland, botanized at Geneva, spent a second winter at Montpellier, and explored Provence and the Camargue : Willughby, who went to Spain, has not left a single record anywhere of any Spanish flora or fauna.

Of his work, Willughby thought that on insects the only part worthy of preservation. This is printed in full with Ray's in the 'Historia Insectorum'. It is a series of small observations, some quite interesting, but showing no grasp of scientific principles. As compared with Ray's it is that of a bright freshman against a lifelong master.

That Ray, the most modest and the most grateful of men (as witness a very touching letter to Courthope), strove to repay Willughby's kindness by completing and publishing in his name the books which they had planned, is a generous act which does credit to them both. It must not be used to impugn Ray's claim to scientific preeminence. On any full study of the evidence it is certain that though Willughby was, as Ray called him, his Maecenas, an invaluable friend and patron, yet Ray wrote the poems. There is no tittle of evidence that they were in the same class as scientists. To estimate their relationship in terms of the Preface to the Ornithology is to mistake a seventeenth-century epitaph for history.

In conclusion it may be permissible to give a few pictures of the man in his work.

No one who lives in Cambridge can read without a thrill the little pages of the Catalogue, and on occasion fancy that a gentle spirit still haunts the little garden beside the Great Gate of Trinity, in which he grew some 700 species of plants—the garden which a few years later passed into the tenancy of Isaac Newton ; or that he climbs with us his familiar Hill of Health and seeing, with dismay, its villas and shrubberies, is yet delighted to find one of his treasures, *Chenopodium Vulvaria*, still surviving the builders' depredations. We go with him to his friend John Worthington at the parsonage of Fen Ditton, and though the paper mill is no more, notice in its leet the 'Potamogeton angustifolium' which gave him so much trouble until he was convinced that Gerard and the Bauhins were wrong and that it was really, as he had always suspected, a *Persicaria*, *Veronica spicata*, still where he found it ; *Anemone Pulsatilla*, which he grew in his garden at Trinity, still on the Gogmagogs ; *Geranium sanguineum* surviving in the one spot in the county where he found it ; *Seseli Libanotis*—he was its first discoverer in Britain, though he only announced his find in 1690 ; above all, *Liparis Loeselii* and the great fen Senecios, proof of how vastly the face of East Anglia has been altered.

Or see him on his travels. The day that he crossed from Cornwall to Devon and wrote : 'on the hill which you ascend after you are come over the passage to go to Plymouth grows *Eryngium vulgare* in great plenty which I do not remember to have seen anywhere else in England'. Or the days in Rome when he haunted the markets and found a bunch of Rock-Thrushes, old and young, and acquired his unrivalled knowledge of the fishes of the Western Mediterranean. Or the great occasion when the hope of many years was fulfilled and he went to Malham Cove, 'one of the wonders of Craven, if not of the world', and saw the slope adjoining that amazing curtain of cliff, blue as it still is with the wild *Polemonium*.

Best of all, see him in his old age, imprisoned by the 'exulcerated pernios', which ate away the flesh of his legs, and were treated by Benjamin Allen (how did Dickens get hold of that name?), by Robinson and Sloane, with ointment of crushed frogs and mercury and innumerable other horrors: surrounded by his four daughters, children under twelve, his admirable wife, and Thomas Simson, his man, in the back room of the cottage at Dewlands which was his study and library and museum, with his apparatus of chip-boxes and breeding-cages, in which 'Jane's Green Geometer' and the caterpillar which he called 'Capito id est Grouthead' were being reared: on that wonderful day in July 1696 when the first recorded Purple Emperor, following upon the first recorded White Admiral, was brought to him from his own county.

That day, and the other five years later, when, now almost bedridden, and struggling with the completion of the third volume of the 'History of Plants', he received a parcel from Edward Lhwyd, lately touring in Ireland, and unpacked the first specimens of the Spring Gentian and St. Dabeoc's Heath, are perhaps the memories of him that are most haunting. It is good to feel, in these days of change and horror, that the thrill with which we first saw the most brilliant beauties of our flora was shared by the veteran naturalist who first explored, described and arranged it.

Discussion.—

Mr. J. RAMSBOTTOM said that all present must have listened with great interest to Dr. Raven's fascinating account of John Ray. He would, however, question Dr. Raven's statement that Ray's work did not receive proper recognition from biologists. Ray was universally regarded as one of the outstanding figures in the history of Botany. Among the treasures of the Department of Botany is John Ray's herbarium. If Dr. Raven could see the reverence with which this was regarded by botanical visitors he would have no doubt about the appreciation of Ray's eminence.

Dr. Raven's new light on John Ray was therefore all the more welcome, and it was to be hoped that the full account would not be unduly delayed.

Mr. I. H. BURKILL reminded the meeting that the Society had given its bust of John Ray a place of honour in the library upstairs.

Mr. S. SAVAGE doubted whether some of the reasons given for the apparent neglect of Ray's work were correct or whether Linnaeus ever deprecated Ray's contributions to Science. The real reason for the apparent neglect surely lay in the reformatations in botanical and zoological systematy carried out by Linnaeus.

OBSERVATIONS AND EXPERIMENTS IN AFRICA BY THE LATE C. F. M. SWYNNERTON ON WILD BIRDS EATING BUTTERFLIES AND THE PREFERENCE SHOWN.

BY G. D. HALE CARPENTER

(Hope Professor of Zoology (Entomology) in the University of Oxford).

THE late C. F. M. Swynnerton, C.B.E., had for many years deeply studied the habits and food of insectivorous birds, particularly in connection with

the extent to which they prey upon butterflies. A short summary of his early experiences was communicated to the Entomological Society of London as long ago as 1915 (Proc. pp. xxxii-xliii), in which he speaks of experiments with captive birds checked by a series of observations and experiments on wild ones. The former were communicated in detail to the Linnean Society (Journ., Zool., xxxiii, pp. 203-385; 1919). A paper on 'Birds in relation to their prey: experiments on Wood-Hoopoes, Small Hornbills, and a Babbler', was published in Journ. S. Afr. Ornith. Union, December 1915, pp. 32-108. Some highly important and interesting work showing the attractiveness of the large *Charaxes* butterflies to birds was published in 1926 (III Internat. Ent. Kongr., Zurich, July 1925, Bd. ii, Weimar, 1926, pp. 478-506). The summary to the Entomological Society stressed the following points, to which attention is again drawn, for it is so often the case that they are forgotten or ignored by critics who wish to prove that there is no selection of food on account of different degrees of distastefulness:—

- (1) 'Unless through sheer impossible hardness, size, etc., there is practically no such thing as "inedibility" A bird will often accept eagerly a low-grade species when hungry enough, or reject a favourite species when replete.'
- (2) 'A bird, given a definite choice, either fails to exercise it as between the things he is hungry enough for, and merely takes each as it comes, or, when he does exercise it, tends to select the largest object that he is at the moment hungry enough to eat This accounts for much that has seemed difficult . . . in my own earlier experiments in which "nauseous" butterflies were taken in apparent preference to pleasanter ones.'

Examples of such apparent inconsistencies will be found in the records now brought forward.

Swynnerton's untimely death has prevented this work being done by the author himself; and it fell to my lot, by his wish, to examine the minutely detailed records. These are too full to be published *in extenso*: moreover, some of them, for one reason or another, are unsatisfactory as not showing anything definite. Consequently, I have devoted much labour to examining, selecting, condensing, and re-writing the mass of data with the results here presented, which do show clearly that the birds exerted choice, often after prolonged and deliberate examination.

These records are grouped in three sections:—

- A. Miscellaneous notes: (1), (2), (3), (4).
- B. Experimental releasing of previously captured butterflies to wild birds: (1), (2), (3), (4).
- C. Experiments on wild birds with butterflies put out as bait, alive, but disabled by removal of part of a wing: I-XXII.

It must be said that fuller conviction of the exercise of choice than can come from perusal of these condensed accounts would be derived from the original detailed notes, which will be kept in the library of the Hope Department of Entomology, Oxford University Museum. A few

of the obviously striking results may be more quickly found from the following reference :—

I. Evidence of special attractiveness of certain species.

The genus *Charaxes* has already been mentioned : throughout this series there is evidence of their prime attractiveness, confirming the results obtained by Swynnerton with his captive birds (e. g. B (2) F, C 12).

The ' Painted Lady ' also rarely failed to attract.

Species of *Precis* were also shown to be very desirable (as in B (3) A).

The Satyrid *Mycalesis campina* Auriv. was usually readily eaten, and the greenish-white Pierid *Catopsilia florella* Fab. seemed often to be preferred.

- II. The attraction of mere size was shown in C 1, C 2, C 15, C 20. In the second of these examples, *Amauris niavius* Linn., which the general results of these experiments, as well as the previous series on captive birds, show to be of low-grade edibility, was taken by a Starred Bush-Robin.
- III. Examples of rejection of apparently distasteful butterflies after seizure can be found in B (2) A, B (2) D, B (3) B, C 1, C 2, C 4, C 8.
- IV. Examples of the obvious ignoring of specimens not at the time desired ;—*Papilio dardanus*, male : B (2) D, B (2) F, B (4) A, C 1 ; in another experiment two were eaten (C 22). *Mylothris* spp. : B (1), B (2) A, B (2) B, B (2) C (in C 1 one was eaten), C 14, C 15, C 21. *Terias* spp. : C 5, C 9, C 14, C 15. *Danaus chrysippus* : B (2) D, B (2) E, B (2) F, B (2) G, B (2) H, B (3) A, C 4, C 15, C 19. *Amauris* spp. : B (2) A, B (2) B, B (2) C, B (2) D, B (2) E, B (2) F, B (2) G, B (2) H, C 3, C 11, C 22. *Planema aganice* : B (2) C. *Acraea* spp. : A 1, B (2) C, B (2) D, B (2) E, B (2) G, B (2) H, B (3) A, B (4) A, B (4) B, C 5, C 12, C 18, C 19.
- V. Cases in relation to mimicry :—*Papilio dardanus*, female form *hippocoon*, mimicking *niavius* C 20. *Hypolimnas dubia* mimicking *Amauris niavius* C 19–20. *Pseudacraea boisduvali* mimicking *Acraea zetes* C 17–18.

The names of species noted in this paper will now be given in full as used by Aurivillius in Seitz's ' Macrolepidoptera of the world ' : 13, Ethiopian Region (Stuttgart, 1925). This well known and readily accessible work is convenient for its plates, in which most of the insects here discussed can be seen.

After this list a name will be given in full only on its first use : subsequently the ' trivial ' name alone will be used, in order to avoid a plethora of technicalities. The trivial names will be found in alphabetical order in the second list, the number after each enabling the memory to be refreshed by quick reference to the full name and systematic position.

In the second list the letter ' A ' indicates that the butterfly is considered to be a typical example of an ' aposematic ' (warningly coloured) species, and therefore relatively distasteful to birds : the letter ' P ' indicates a characteristically ' procryptic ' or concealed (at least when at rest) species, relatively more edible to birds.

FULL NAME.

PAPILIONIDAE.

1. *Papilio d. dardanus* Brown, with female form *hippocoon* Fab.
2. *P. echerioides* Trim.
3. *P. nireus lycaeus* Dbl.
4. *P. demodocus* Esp.
5. *P. pylades angolanus* Goeze
6. *P. l. leonidas* Fab.
7. *P. antheus* Cr., form ?
8. *P. polices* Cr.
9. *P. porthaon* Hew.

PIERIDAE.

10. *Leptosia medusa* Cr., form ?
11. *Mylothris agathina* Cr.
12. *M. rueppelli* Koch.
13. *M. yulei* Btlr.
14. *Pieris* (*Belenois*) *gidica* Godt., form ?
15. *P. (B.) severina* Cr., form ?
16. *P. (B.) mesentina* Cr., form ?
17. *Eronia thalassina* Bdv.
18. *E. argia* Fab.
19. *Catopsilia florella* Fab.
20. *Terias senegalensis* Bdv.
21. *T. desjardinsi regularis* Btlr.
22. *T. brigitta* Cr.

DANAIDIDAE.

23. *Danaus c. chrysippus* Linn.
24. *Amauris niavus dominicanus* Trim.
25. *A. o. ochlea* Bdv.
26. *A. a. albimaculata* Btlr.
27. *A. l. lobengula* E. Sh.

SATYRIDAE.

28. *Melanitis leda africana* Fruhst.
29. *Mycalesis safitza* Hew.
30. *M. campina* Auriv.
31. *Henotesia perspicua* Trim.
32. *Ypthima* sp.

NYMPHALIDAE.

33. *Charaxes brutus natalensis* Stgr.
34. *Ch. pollux geminus* Rthsch.
35. *Ch. candiope* Godt.
36. *Ch. z. zoolina* Wwd.
37. *Hamanumida daedalus* Fab.
38. *Pseudacraea boisduwali trimeni* Btlr.
39. *Neptis saclava marpessa* Hpffr.
40. *N. swynnertonii* Trim.
41. *N. agatha* Stoll
42. *N. melicerta* Drury

43. *N. goochi* Trim.
44. *Crenis boisduwali* Wallengr.
45. *Crenis natalensis* Bdv.
46. *Byblia a. achelota* Wallengr.
47. *Eurytela hiarbas lita* R. & J.
48. *E. dryope angulata* Auriv.
49. *Hypolimnias dubia mima f. wahlbergi* Wallengr.
50. *Salamis parhassus aethiops* Pal.
51. *Catacroptera c. cloanthe* Cr.
52. *Precis terea elgiva* Hew.
53. *P. a. archesia* Cr.
54. *P. t. tugela* Trim.
55. *P. ceryne* Bdv.
56. *P. a. antilope* Feisth.
57. *P. octavia sesamus* Trim.
P. o. natalensis Stgr.
58. *P. cebrene* Trim.
59. *P. clelia* Cr.
60. *P. orithyia madagascariensis* Guen.
61. *Pyrameis cardui* Linn.
62. *Antanartia schaeneia* Trim.
63. *Atella phalantha* Drury.

ACRAEIDAE.

64. *Planema a. aganice* Hew.
65. *Acraea esebria* Hew., form ?
66. *A. johnstoni* Godm., form ?
67. *A. igola* Trim.
68. *A. cabira* Hpff., form ?
69. *A. terpsichore* Linn., form ?
70. *A. natalica* Bdv., form ?
71. *A. oncaea* Hpff.
72. *A. caldarena* Hew., form ?
73. *A. asema* Hew.
74. *A. egina areca* Mab.
75. *A. zetes acara* Hew.
76. *A. anemosa* Hew.
77. *A. neobule* D. & H.
78. *A. rabbaiae* Ward.

HESPERIIDAE.

79. *Rhopalocampa libeon* Drc.
80. *R. forestan* Cr.
81. *R. pisistratus* Fab.
82. *Platylesches moritili* Wallengr.
83. *Padraona zeno* Trim.
84. *Parnara borbonica* Bdv.
85. *P. detecta* Trim.
86. *P. mathias* Fab.
87. *Gegenes hottentota* Latr.
88. *Sarangesa djaelaetae* Wallengr.
89. *Hesperia*.

TRIVIAL NAME.

<i>acheloia</i> , 46.	<i>detecta</i> , 85.	<i>nireus</i> , 3.
<i>aganice</i> , 64, A.	<i>djaelaclae</i> , 88.	<i>ochlea</i> , 25, A.
<i>agatha</i> , 41.	<i>dryope</i> , 48.	<i>octavia</i> , 57.
<i>agathina</i> , 11, A.	<i>dubia</i> , 49.	<i>oncaea</i> , 71, A.
<i>albimaculata</i> , 26, A.	<i>echerioides</i> , 2.	<i>orithyia</i> , 60.
<i>anemosa</i> , 76, A.	<i>egina</i> , 74, A.	<i>parhassus</i> , 50.
<i>antheus</i> , 7.	<i>esebria</i> , 65, A.	<i>perspicua</i> , 31, P.
<i>antilope</i> , 56, P.	<i>florella</i> , 19.	<i>phalantha</i> , 63.
<i>archesia</i> , 53, P.	<i>forestan</i> , 80.	<i>pisistratus</i> , 81.
<i>argia</i> , 18.	<i>gidica</i> , 14.	<i>policenes</i> , 8.
<i>asema</i> , 73, A.	<i>goochi</i> , 43.	<i>pollux</i> , 34.
<i>boisdwuali</i> , 38.	<i>Hesperia</i> sp., 89.	<i>porthaon</i> , 9.
<i>boisdwuali</i> , 44.	<i>hiarbas</i> , 47.	<i>pylades</i> , 5.
<i>borbonica</i> , 84.	<i>hippocoon</i> , 1.	<i>rabbanae</i> , 78, A.
<i>brigitta</i> , 22, P.	<i>hottentota</i> , 87.	<i>rueppelli</i> , 12, A.
<i>brutus</i> , 33.	<i>igola</i> , 67, A.	<i>sacclava</i> , 39.
<i>cabira</i> , 68, A.	<i>johnstoni</i> , 66, A.	<i>safitza</i> , 29, P.
<i>caldarena</i> , 72, A.	<i>leda</i> , 28, P.	<i>schæneia</i> , 62.
<i>campina</i> , 30, P.	<i>leonidas</i> , 6.	<i>senegalensis</i> , 20, P.
<i>candiope</i> , 35.	<i>libeon</i> , 79.	<i>severina</i> , 15.
<i>cardui</i> , 61, P.	<i>lobengula</i> , 27, A.	<i>swynnertoni</i> , 40.
<i>cebrene</i> , 58, P.	<i>mathias</i> , 86.	<i>terea</i> , 52, P.
<i>ceryne</i> , 55, P.	<i>medusa</i> , 10.	<i>terpsichore</i> , 69, A.
<i>chrysippus</i> , 23, A.	<i>melicerta</i> , 42.	<i>thalassina</i> , 17.
<i>clelia</i> , 59, P.	<i>mesentina</i> , 16.	<i>tugela</i> , 54, P.
<i>cloanthe</i> , 51.	<i>moritih</i> , 82.	<i>Ypthima</i> sp., 32, P.
<i>daedalus</i> , 37.	<i>natalensis</i> , 45.	<i>yulei</i> , 13, A.
<i>dardanus</i> , 1.	<i>natalica</i> , 70, A.	<i>zeno</i> , 83.
<i>demodocus</i> , 4.	<i>neobule</i> , 77, A.	<i>zetes</i> , 75, A.
<i>desjardinsi</i> , 21, P.	<i>niavius</i> , 24, A.	<i>zoolina</i> , 36.

The names of the birds concerned in this paper, as given by Swynnerton in his notes, were incomplete or required revision, or both. They were taken to Mr. W. B. Alexander, of the Edward Grey Ornithological Institute at Oxford, who kindly revised them according to Scater's 'Systema Avium Aethiopicarum' (1924-30). I have placed them in alphabetical order of genera, by which they will be mentioned:

Arizelocichla m. milanjensis (Shelley). Milanje Stripe-cheeked Greenbul.

Centropus senegalensis fasciopygialis Reichw. Nyasaland Coucal

Chlorophoneus rubiginosus bertrandi (Shelley). Nyasa Rufous-breasted Bush-Shrike.

Cisticola sp. Not identified by MS.

Coracina c. caesia (Licht.). Grey Cuckoo-Shrike.

Dicrurus l. ludwigii (Smith). Ludwig's Square-tailed Drongo.

Ispidina picta natalensis (Smith). Natal Pygmy Kingfisher.

Laniarius ferrugineus, probably *mossambicus* (Reichw.). Bou-bou.

Merops apiaster Linn. European Bee-eater.

Pogonocichla stellata transvaalensis (Roberts). Transvaal White-starred Bush-Robin.

Pogonocichla (Swynnertonia) swynnertoni (Shelley). Swynnerton's Bush-Robin.

Pycnonotus tricolor layardi Gurney. Black-capped Geelgat (Bulbul).

Saxicola torquata robusta (Tristr.). Stonechat.

Tchitrea perspicillata plumbeiceps (Reichw.). Zambesi Red Paradise Flycatcher.

The observations and experiments were conducted by Swynnerton on his farm Gungunyana in the Chirinda forest, Melsetter, Southern Rhodesia.

SECTION A. MISCELLANEOUS NOTES.

(1) *Behaviour of butterflies in the presence of hunting birds.*

Swynnerton records that on 7 March 1911 he walked eighteen miles, partly through savanna woodland, partly through open grass savanna, and returned the next day. 'During these walks I kept a particular look-out for birds attacking butterflies: a fair number of butterflies were about until I came on an enormous flock of European swallows hawking backwards and forwards over the grass, and with them between one and two hundred bee-eaters (*Merops*) crowding the branches of a large dead tree and thence flying off after small insects. Not a single butterfly was seen in the area under search, though I slowed up and watched carefully.' On coming into a second, smaller, flock of swallows the first butterfly was seen, 'a *Terias* which I kicked up accidentally and at once dived into the long grass and refused to rise again for more than a few feet at a flight. What was almost certainly a small *Lycaenid* was snapped up by a swallow about thirty yards away. A little further on a female *Acræa caldarena* Hew. was flying slowly and aimlessly about, just above the grass-heads—a conspicuous object. At least a dozen swallows passed it within a foot, and numbers more at distances varying from ten to twenty feet, but not one of these took the slightest notice of it, nor did the *Acræa* go to ground however closely approached. Immediately beyond the swallows I once more commenced to see butterflies . . . The behaviour of the *Terias* and *Acræa* respectively, and the general absence of butterflies, usually through their having hidden below the herbage, is quite in line with what I have observed on various other occasions when a large flock of birds was present' (cf. Sect. A (2), B (2) A).

(2) *Attacks under cover.*

On the forest outskirts two *Terias senegalensis* Bdv., after circling round each other, disappeared into a shrub in which an *Arizelocichla* was searching for insects. A few seconds afterwards the bird suddenly flew up, appeared to take some object from under a leaf, and flew across to the forest with a brilliant yellow object in its bill. On beating the bush only one *Terias* was obtained. On another occasion in the late afternoon a number of butterflies, *Eurytela hiarbas* Drury and *Mycalesis campina* Auriv., were flitting about and settling on leaves of a tangle of *Dioscorea* in a small open space in the forest. 'I carefully watched a pair of Mlanje bulbuls (*Arizelocichla*) that were searching the outer foliage from inside, and had the pleasure of seeing one of them slip out stealthily between the leaves and quietly take one of the basking butterflies . . . This is a type of attack which is constantly taking place from just below the shrub canopy, or from under the panicles of flowers, by the "searching" birds. Numerous butterflies must be taken, and, be it noted, they tend strongly to display the upper surface of their wings when thus basking or feeding.'

(3) *Damage inflicted on wings.*

Marshall and Poulton (1902, pp. 366-75 and pl. ix. x, xi.) drew particular attention to the importance of certain kinds of injury to the wings of butterflies as evidence of attacks by birds. Swynnerton, in the following observations, described how such damage is inflicted. On 30 April 1911 he was watching a drongo (*Dicrurus*) at the edge of the forest, low down. He released a captured *Charaxes brutus natalensis* Stgr., which flew to the bushes and was at once struck at by the drongo as it was about to settle. The bird made repeated snaps at the butterfly before it dived into long grass, and at the third attack a small wing fragment flew out. Swynnerton captured the *brutus* in his forceps and found a small piece taken from the right hind wing—a shallow notch such as may often be seen. The drongo then went into the forest and another *brutus* was released: the bird struck at it and missed and the *brutus* 'went to ground' pursued by two birds, 'and there was much snapping of bills before the butterfly reached the shelter of short dense grass'. The butterfly was examined and found to have acquired 'a deep irregular incision in the right hind wing a little above the anal angle'. It was released again and, having flown about five yards, settled on a leaf: a drongo dashed at it from twelve yards away, dislodged it, and caught it in the air and disappeared (see below, Sect. B (3) B).

(4) *Evidence of discriminative inspection by birds.*

Swynnerton records that a friendly naturalist reported having seen a bulbul (*Pycnonotus*) that was playing with its mate break off to dash after an *Acraea terpsichore* Linn., which got up suddenly. On reaching it the bird 'checked itself suddenly with outspread wings and legs and turned back without an attempt at capture'.

On 4 April 1911 Swynnerton was carrying out one of the experiments of which many are reported later, by releasing captured butterflies in the presence of birds. There was a flock of bee-eaters on flowering Eucalyptus trees. The butterflies *Acraea egina areca* Mab., *Amauris l. lobengula* E. Sh., and *A. a. albimaculata* Btlr. were released well in view of the birds, which neglected them. But a male *Papilio d. dardanus* Brown having been released, and flying slowly, after it had gone about eighty yards, was suddenly flown at by a bee-eater which 'halted in the air to inspect, a few feet above it, and at once returned to the others without attempting to attack it'. A score of *Belenois* fluttering over the ground were not at all attacked, but two *Charaxes candiope* Godt. released were at once swooped at, but got into cover before they could be caught. On 30 April similar experiments were being made with a drongo. A male *Papilio e. echeriodes* Trim. which was released was damaged and 'merely fluttered for two or three seconds in the air and then swayed to the ground'. The drongo flew straight out at it but turned back just before reaching it. Swynnerton suggests that it recognized the insect as something for which it was not hungry enough at that time: it may have mistaken the *Papilio* for *brutus*, so freely eaten by birds (cf. also an item *infra*, Sect. B (2) F.)

SECTION B. EXPERIMENTAL RELEASING OF CAPTURED BUTTERFLIES TO WILD BIRDS IN NATURAL ENVIRONMENT.

The following are condensed extracts from the long accounts of observations and experiments upon wild birds. In this series the butterflies, having been placed alive in paper envelopes, were released within sight of insectivorous birds. Part of a fore wing was cut off in the case of powerful species so as to prevent flight being so rapid that events could not be followed.

(1) *Ispidina picta natalensis* (Smith).

This kingfisher was on a twig, eight feet from the ground, watching insects. Diptera and Hymenoptera passed and repassed quite close, but no attempt was made to catch them. A *brutus* and a *candiope*, each with half the right fore wing cut off, were watched with interest only. Then the bird suddenly flew down, picked up a small grasshopper and, having taken it to the perch, swallowed it after much battering. A *Mylothris gulei* Btlr. flew very slowly within a foot of the bird, which ignored it entirely. Swynnerton then heard the 'rustle' of the wings of a *Charaxes* and, turning, saw the kingfisher with a *brutus* half-way down its throat, which was eventually swallowed. [Note.—The slowly flying, conspicuous *Mylothris* was ignored, but the much larger *Charaxes* eaten.]

(2) *A. Merops apiaster* Linn.

This observation concerns attacks on butterflies at liberty under natural conditions. Some passing *Merops*, travelling fast and high at 3.30 p.m., swooped down over flowers of *Zinnia* attended by butterflies, some of which were captured, as follows:—(1) Unrecognizable; (2) *Acraea neobule* D. & H., seized and rejected: it was damaged but not killed; (3) one bird flew from the perch a dozen times, on two occasions returning with 'a fairly large butterfly', not identified, both eaten; (4) a male *egina* passed the perch within a few yards: a bee-eater flew out but returned, leaving the butterfly untouched; (5) a passing bee-eater rose to an *Amauris* high in the air, which was seen by field-glasses to be of the *albimaculata* type. The butterfly was held lengthwise in the bill by the body, with wings flapping, and then was released and flew off. Another flock of *Merops* now came to some flowering Eucalyptus trees, and for more than twenty minutes hawked round the flowers, apparently catching bees. Then they went into a plantation of coffee and hawked small fry for half an hour. Two attacks on butterflies were seen: (6) on a *candiope* which, after dodging, dropped like a stone into dense weeds and remained there [cf. Sect. A (1)]; (7) an *albimaculata* which got up close to the birds was ignored, and also a *Mylothris*; (8) ten minutes later a *Lycaenesthes lodes* Hew. got up and was at once caught and swallowed. [Note.—The typically warningly-coloured species of *Acraea*, *Amauris* and *Mylothris* were ignored, or not eaten when other butterflies were attacked or eaten.]

(2) B. Parties of *Merops* visited the locality, in each case first eating bees attracted to Eucalyptus flowers. One party was followed into a coffee plantation and the following events seen:—(1) A small *Lycaenid*

was captured : (2) a species of *Mylothris* ran the gauntlet of four of the bee-eaters, none making any attempt to capture it ; they then went to a dead tree ; (3) an *albimaculata* and an *Atella phalantha* Drury passed close and were ignored : (4) immediately afterwards a *candiope* was caught and swallowed, wings and all ; (5) a little way off a *yulei* ran the gauntlet of eight bee-eaters unattacked ; (6) one caught and swallowed a Lycaenid ; (7) all made off, but one caught a *Neptis*. [Note.—An aposematic *Mylothris* was twice ignored, but other species eaten. *Charaxes candiope* was preferred to *Amauris albimaculata* and *Atella phalantha*.]

(2) C. About eighty *Merops* came to hawk bees at Eucalyptus flowers : three of them went into the coffee plantation and were followed. (1) One caught and ate a Lycaenid ; (2) one caught and rejected 'a small butterfly' ; The birds moved on and were joined by others : the only butterflies observed were *yulei*, *Belenois severina* Cr. and *albimaculata*, which flew among the birds and were ignored ; (3) a *brutus* was released, then a *candiope*, both being hotly pursued : the *brutus* went down among the bushes but the *candiope* was lost to sight ; (4) a female *Acraea igola* Trim., hovering over a bush, was swooped upon by a bee-eater which swerved off within nine inches without attempting to take it : it settled conspicuously on a leaf, waving its wings unmolested, while bird after bird passed within a few feet ; (5) a *lobengula* came sailing through the crowd, and a *Planema a. aganice* Hew., both being ignored ; (6) a captured 'Skipper', *Rhopalocampta libeon* Drc., thrown up into the air, was pursued by several of the bee-eaters, one of which ate it. [Note.—Two species of *Charaxes* were preferred to *Amauris albimaculata*, *Mylothris yulei* and a *Belenois* : *Amauris lobengula* and *Planema aganice* were ignored, but the smaller *Rhopalocampta libeon* eaten.]

(2) D. A number of *Merops*, having fed well on bees, were on branches awaiting choicer morsels. Swynnerton released for them thirty-three butterflies as follows, though not in order of the names (edible and distasteful species were released alternately) :—*Papilio dardanus*, males, two ; *P. nireus lyaeus* Dbl., two ; *Danaus c. chrysippus* Linn., one ; *lobengula* and *albimaculata*, eleven ; *brutus*, nine ; *candiope*, five ; *Hamannimida daedalus* Fab., one ; *hiarbas*, one ; *Acraea johnstoni* Godm., one ; *A. esebria* Hew., one male and one female. The following notes were made :—At about the thirteenth release a *nireus* was ignored, also another, but several *Charaxes* were captured. A male *dardanus* was seized and rejected : it fell slowly from a height, but no other bird attempted to catch it. A *candiope* captured high in the air escaped but was chased and caught again, while several other birds also dived after it, two even chasing the captor. The second *dardanus* flew to and fro in front of birds which ignored it : the *hiarbas* was also ignored. The two *Acraea*, the *chrysippus* and the majority of the *Amauris* gave magnificent chances, but no attempt was made to attack any of them, even when they doubled back, although every *Charaxes* which did the same was at once captured. Eleven of the fourteen *Charaxes* were at once pursued, and Swynnerton saw eight of them captured. [Note.—The preference for *Charaxes* and dislike of *Danaus*, *Amauris* and *Acraea* are well shown. Neither species of *Papilio* was liked.]

(2) E. A party of about twenty *Merops* were hawking around Swynerton, who released for them two *brutus* and one *candiope*, all of which were captured. A wild *lobengula* and *albiculata* flew right through the party, attracting no attention. Released specimens of *chrysippus*, *caldarena* and *johnstoni*, which would have been easier to catch than *Charaxes*, were not attacked. [Note.—Two species of *Charaxes* were preferred to *Danaus*, two species of *Amauris* and two of *Acraea*.]

(2) F. Several *Merops* were hawking from dead branches, and Swynerton released butterflies for them as follows: (1) A *candiope*, at once snapped up by a bird on the wing. (2) *Antanartia schaeenei* Trim., *Eronia argia* Fab. and *Catopsilia florella* Fab., all good marks for the birds, were ignored. (3) A *brutus*, at once attacked from a distance by three birds, was seized by the first-comer. (4) A male *dardanus* was swooped at and struck by one of the birds, but it fell to the ground and the bird passed on. Apparently the bird decided, just as it struck, that it did not want the butterfly (vide supra, Misc. notes, Sect. A (4)). (5) A number of butterflies, of which the order of release was not kept: *yulei*, one; *Terias brigitta* Cr., one; *chrysippus*, four; *albiculata*, thirteen; *lobengula*, five; *brutus* and *candiope*, eighteen; *Ch. zoolina* Wwd., one; *igola*, one; *Acraea natalica* Bsd., one; *A. oncaea* Hpffr. and *caldarena*, seven; *egina*, one. Not a single Danaid or Acraeid was touched, nor the Pierid-like *zoolina*, but only two of the eighteen other *Charaxes* escaped attack. In addition, two wild *Belenois* spp. and two *chrysippus* ran the gauntlet without being attacked. [Note.—Two species of *Charaxes* were overwhelmingly preferred to Danaiids and Acraeids, not one of which was touched.]

(2) G. Three *Merops* were in the glen usually frequented. Quite a number of *Belenois severina*, *mesentina* Cr., and *gidica* Godt passed the birds before and during the experiment, but not one was attacked. The following butterflies were released to the birds:—(1) Two female *florella* and an *argia*, which were unmolested. (2) Two *candiope* and two *brutus*: three of these were carried off, one doubled back away from the birds and escaped. (3) One *chrysippus*, three *Amauris* (*albiculata* and *lobengula*), and one *Acraea asema* Hew. were all ignored. (4) A *candiope*, as soon as it came round a tree-trunk into sight of a bee-eater perched higher up, was at once attacked: the bird returned to the perch without it. (5) A *brutus* was captured, 'but the bird had the greatest difficulty in holding it, and for several minutes the two swayed about in the air, now up, now down, the *Charaxes* beating vigorously with its free wings and several times evidently nearly slipping from the bird's grasp. Finally, very high in the air, it actually did so, and half a dozen birds that had been attracted by the spectacle from considerable distances—none had been in sight at the commencement—dashed for it simultaneously, and after the usual confusion and snapping of bills one of them seized it and made off, followed closely by two others that were disposed to dispute its possession'.

Two other *Merops* were hawking in another locality and were joined by four others: one of them snapped up and ate a Lycaenid. A *brutus* was released and was at once carried off: a *Charaxes* z. *zoolina* Wwd. was completely neglected; another *brutus* was at once seized: the *zoolina*, having been netted, was again released, 'looking very like a Pierine as it

flew', and was ignored: a *Belenois* and an *egina* that flew past were also ignored. The following which were released were similarly treated: a *chrysippus*, five *albimaculata* and *lobengula*, and a *caldarena*. [Note.—*Charaxes brutus* and *candiope* were again preferred to Danaids and Acraeids. The smaller *zoolina* of Pierine appearance, *Belenois* and *Catopsilia* were not desired: a Lycaenid was eaten.]

(2) H. Many *Merops* were busy among trees, where a swarm of bees attracted them. A *candiope* which suddenly appeared was at once chased. The birds having taken up prominent stations on perches, Swynnerton released for them two *chrysippus*, nine *albimaculata* and *lobengula*, one *johnstoni*, one *egina*, and one *caldarena*. All were ignored. A *nireus*, feebly flying on account of a missing hind wing, was released, recaptured, and released three times without any notice having been taken by the birds, of which there were six on a twig. It settled, and a bee-eater, previously unseen, dashed up to it, but on reaching it wheeled round and returned. A female *florella* and an *Eronia thalassina* Bdv. were released, but were not attacked: a *candiope* was at once carried off. [Note.—*Charaxes candiope* was preferred to Danaids, Acraeids, *Catopsilia florella* and *Eronia thalassina*.] Swynnerton comments on this experiment: 'A point which applies to other experiments on the same birds [? same kind of bird] is the large number of refusals on sight, showing the bee-eaters' good knowledge of their butterflies, obviously the result of experience.'

(3) A. *Tchitrea perspicillata plumbeiceps* (Reichw.).

Two paradise flycatchers were in an Acacia. Swynnerton released to them a female *esebria* and a *chrysippus* which flew slowly in full view of the birds, the latter butterfly twice passing them: both were ignored. A *florella* flew quickly in the opposite direction unattacked. Then a *Preis cebrene* Trim. was released: it rapidly crossed an open space, settled for an instant on a flower and was 'dexterously snapped up' when it rose again by a flycatcher, which took it to a high tree, battered, and swallowed it.

(3) B. A recently flown nestling *Tchitrea* appeared in an Acacia near the house. A *florella* was liberated: it was attacked but only lost a piece from a wing, and escaped by diving into herbage (cf. Sect. A (3)). A *Papilio pylades angolanus* Goeze had the same experience. The bird then seized a passing wild *neobule*, took it up to a branch, tasted, and rejected it. The butterfly flew away apparently unharmed. A second released *angolanus* was attacked, and the bird flew to its perch with 'quite a large piece of wing in its bill,' the butterfly escaping (cf. Sect. A (3)).

(4) A. *Dicrurus ludwigii* (Smith).

A drongo had taken up its position near the house. A *Pyrameis cardui* Linn. was released and flew strongly away: the drongo flew out to it—27 yards—captured it in mid-air and swallowed it. A *terpsichore*, then released, was watched by the drongo from within two feet of its perch, but was left alone. Several *caldarena* were also ignored. A *senegalensis* and a *caldarena* were then released in the verandah. The drongo dashed quickly in, neglected the *Acraea*, seized the *Terias* and passed on and out with it. Shortly afterwards it returned to the tree,

absolutely ignored a *lobengula* and several more *caldarena*, but at once dashed out to a very large *senegalensis* and ate it.' [Note.—The Pierine *Terias* was definitely preferred to *Acraea*.]

(4) B. Just before sunset a drongo appeared in the tree beside the verandah. The following butterflies were released for it. (1) A *cardui*. This flew to thirty yards away, but the drongo flew after it and caught it, and retreated into shelter. (2) *Rhopalocamptu*, either *pisistratus* F. or *forestan* Cr. This dashed past the foliage when the drongo dashed out and caught it. Swynnerton says 'I was filled with admiration for the suddenest, swiftest, and cleverest thing I had ever witnessed'. (3) A female *caldarena* sailed about in full view of the tree but failed to draw an attack. (4) A *forestan* flew towards the tree where the drongo was, doubled back, and was followed up and captured by the drongo, which returned to the tree. [Note.—The Hesperiid *Rhopalocamptu forestan* was preferred to *Acraea caldarena*.]

SECTION C. EXPERIMENTS WITH 'PLANTED' BUTTERFLIES.

The following experiments were devised by Swynnerton 'to bring to light the views on butterflies held by the searching birds of the undergrowth, the details of the feeding of which one has so little chance of observing'.

The site chosen was at the edge of the estate, where 'a hedge of *Solanum*, very wide, tall, thorny, and dense, and much overgrown with *Hypoestes*, *Leonotis*, etc., runs along the northern outskirts at from 5 to 20 yards from the forest. A ditch about two feet six inches deep and of the same width runs alongside the hedge on its forest side for a considerable distance I had cleared the ditch of weeds and dry leaves, had cut out a convenient seat for myself at the end of it and had cut an opening through the hedge at that particular point out into the coffee field beyond'.

The method of experiment was to 'plant' butterflies, freshly caught, but prevented from flying by the removal of more than half a fore wing. A few died, but the majority, 'after a few initial movements, settled down for the most part to rest, with closed wings'.

The spots where the butterflies were put out were :—

A 1, in the ditch, at some distance from my seat ; B 1, in the hedge, only two yards from myself ; A 2, in the ditch, only six or seven yards from myself ; B 2, rather further through the hedge than B 1 ; B 3, right away from hedge, but visible to birds perched on top of the hedge.

The birds which were observed to pay attention to this bait were *Laniarius* (Boubou) ; *Pogonocichla* (Starred Bush-Robin) ; *Swynnertonia* (Swynnerton's Bush-Robin) ; and *Cisticola* sp.

Experiment I. Swynnerton put out butterflies at 11 a.m. and watched until 4 p.m. ; his detailed observations cannot be given for publication *in extenso*, which is unfortunate, because they are so much more convincing than a summary or tabulated statement, such as the following.

The letter and figure preceding the name refer to the locality as described above. E signifies eaten or not found at the end of the experiment. N signifies found uneaten.

Papilio. B 2, 1 *dardanus*, ♂, N; B 2, 1 *echeroides*, ♂, E; A 1, 1 *nireus*, E; B 1, 1 *nireus*, E; B 2, 1 *nireus*, E; A 1, 4 *pylades*, 3 E, 1 N; B 2, 1 *pylades*, N; B 3, 2 *pylades*, N.

Pieridae. A 2, 1 *medusa*, N; A 1, 1 *Mylothris agathina* Cr., E; A 1, 3 *mesentina*, 2 E, 1 N; A 1, 1 *argia*, E; B 1, 2 *florella*, N; B 3, 1 *florella*, E; A 1, 1 *brigitta*, N.

Danaididae. A 1, 3 *chrysippus*, N; A 1, 1 *Amauris n. niavius* L., N; B 3, 2 *albimaculata*, N; A 1, 1 *lobengula*, N.

Satyridae. A 1, 1 *Ypthima* sp., E; A 1, 2 *Henotosia perspicua* Trim., N; B 3, 1 *perspicua*, N.

Nymphalidae. A 1, 4 *Neptis agatha* Stoll, 1 E, 3 N; A 2, 1 *agatha*, N; B 1, 1 *N. melicerta goochi* Trim., E; A 2, 1 *Eurytela dryope angulata* Auriv., N; B 3, 1 *Precis t. tugela* Trim., E; A 1, 2 *P. cebrene* Trim., N; B 2, 1 *cebrene*, N; B 3, 1 *cebrene*, E; A 1, 1 *P. clelia* Cr., E; B 2, 1 *clelia*, N; B 1, 1 *P. orithyia madagascariensis* Guén., N; A 1, 11 *cardui*, E; B 1, 7 *cardui*, 6 E, 1 N; B 2, 3 *cardui*, 2 E, 1 N; A 2, 2 *cardui*, E; B 3, 1 *cardui*, E.

Acraeidae. B 3, 1 *aganice*, E; A 1, 2 *johnstoni*, N; B 3, 1 *terpsichore*, N; A 1, 1 *natalica*, N; A 1, 1 *A. anemosa* Hew., E; A 1, 1 *A. rabbaiae* Ward, N.

Hesperiidae. A 1, 1 *forestan*, E; A 2, 1 *Padraona zeno* Trim., E; A 2, 1 *Parnara* sp., N; A 2, 1 *Gegenes hottentota* Latr., E; A 2, 1 *Hesperia* sp., N.

Swynnerton commented on this experiment as follows:—Not one of the birds concerned appeared to show the slightest repugnance to butterflies as such. All that I saw eaten were apparently eaten readily, even eagerly, with the one or two exceptions indicated [in the MS.]. The *Pogonocichla* showed a very definite and strong preference for *cardui* against whatever other butterflies it saw and recognized in the different groups . . . it speedily picked out a *cardui* on each of three successive visits to A 1 . . . In A 2 it picked out the only *cardui* among eight butterflies, and passed over a fluttering *nireus* to take a *cardui* in B 1. *D. chrysippus* was definitely rejected after trial, yet the bird clearly showed that it was ready to eat butterflies of this size and larger, both by trying the *chrysippus* and by eating an *argia* and seizing a *nireus* which sudden fright made it drop . . . Three further rejections after trial were witnessed, one of them probably *johnstoni*, the other two could not be recognized. The bird was by no means taking anything that came or anything below a certain size: it was definitely rejecting some species on sight or after trial, and as definitely selecting others.'

The *Swynnertonia* definitely tasted and rejected three species—*chrysippus*, *mesentina* and a specimen which may have been one of the paler *Acraea*, *johnstoni* or *A. rabbaiae*. The two former do not enter the rain-forest proper, which is the main haunt of this ground-feeding bird.

The Bou-bou (*Laniarius*) probably illustrated, by 'first taking *nireus*, the principle of selection of the largest'. Later, having been hungry enough to eat a moving *Mylothris* which attracted his attention, he visited another dump and was replete enough to pass over the larger *nireus* and *dardanus*. The shrike also visited dump B 3 and ate a *cardui*, *tugela*, two *agatha* and a male *florella*, leaving *aganice* and *albimaculata* untouched (these two are typically aposematic species, believed to be relatively

distasteful). 'Throughout this period the shrike gave the impression of being relatively replete.'

A glance at the table shows that, out of twenty-four *cardui*, disposed over five dumps, all but two were eaten. Not one of seven Danaididæ, belonging to four species, was eaten, and out of seven Acraeidae, of six species, only two disappeared, and these were not seen to be eaten. Moreover, on several occasions specimens that appeared to be Acraeas were tasted and rejected. It is rather remarkable that out of eight *Precis*, of seven species, five were found uneaten. Their escape may have been due to their extremely inconspicuous, procryptic undersides, for they have the habits of truly edible species.

Experiment II. At site A 1 were laid down (singly, unless otherwise stated) *pylades*, *agathina*, *mesentina*, *florella*, *brigitta*, 3 *chrysippus*, *niavius*, *lobengula*, *Mycalesis safitza* Hew., 2 *perspicua*, 3 *agatha*, 2 *orithyia*, 2 *cebre*ne, 2 *cardui*, *rabbaiæ*, *johnstoni*, *natalica*, *Parnara detecta* Trim. At B 1, *florella*, *melicerta*, *orithyia*, *cardui*. At A 2, *agatha*, *dryope*, 3 *hottentota*, 1 *Eretis djaelaelæ* Wallgr., 6 *zeno*, 2 *detecta*. At B 2, ♂ *dardanus*, *angolanus*, *cebre*ne, *clelia*, *cardui*, *terpsichore*. At B 3, 2 *pylades*, *orithyia*, 2 *albimaculata*, *perspicua*, *terpsichore*, 1 light-coloured Geometrid moth.

Unfortunately, the notes which Swynnerton made on the specimens remaining at the end of the experiment were lost by him, so that an account as complete as that for Experiment I cannot be given. 'In all the experiments thirty attacks by birds were witnessed, but the added evidence of absentees and wing-damage suggest that half as many more took place. . . . All the birds concerned showed the *greatest* readiness to take butterflies.' The following comments were made by the experimenter: 'A Starred Bush-Robin (*Pogonocichla*) took a butterfly of the dull appearance of *Precis* out of a host of larger and more conspicuous species at A 1. It took six "skippers" out of the twelve at A 2, leaving *dryope* and *agatha*, and later took another "skipper", then two more, and what seemed to be the *dryope*. A considerable time afterwards a bush-robin, probably hungry or having just cast a pellet, took and ate *niavius*, the largest butterfly present, probably on the principle of taking the largest for which it was hungry enough. Then, leaving other large and highly conspicuous Danaididæ unattacked, it ate a male *florella* (or *pylades*: it was not clearly seen) and what seemed to be *agathina*. This is completely in line with my results from birds in captivity: after a pellet has been ejected, or in hunger, anything may be eaten, the larger the better. Increasing discrimination is shown with gradual growth of repletion.

The *Laniarius* started with an *albimaculata*; on his next visit he discriminated, selecting not the largest but the dull, pleasant *cebre*ne and *cardui*: on his next visit he rejected, after trial, *terpsichore* and male *dardanus* but readily ate a *cardui*.

The ground cuckoo (*Centropus*) showed a preference for *florella* against *pylades*, but was frightened off. It ate an unrecognized species.

A *Swynnertonia* seized a free 'skipper', not of the experimental material, and a *Coracina* took a wild *Melanitis leda* L.: also a *Dicrurus* took a *zeno*. Swynnerton also calls attention to the 'rôle of the forest bulbuls, which *flush* resting butterflies for themselves and the aerial predators to seize'.

He concludes the account of this experiment thus: 'In this experiment quite thirty attacks were witnessed, but the added evidence of absentees and wing-damage suggest that half as many more took place.'

Experiment III. The birds noted in this experiment were two bush-robins (*Pogonocichla*), the Boubou (*Laniarius*) and another shrike (*Chlorophoneus*).

Slightly different sites were chosen, as the shadows in the ditch had sometimes prevented clear vision. A little distance away from the observation post the ditch was bridged by a thick root, forming site A. On the bridge and in the ditch at A were placed (singly, unless otherwise noted) *Papilio demodocus* Esp., 2 *pylades*, *florella* (male), *niavius*, *albimaculata*, *safitza*, *cebreue*, 4 *cardui*, *egina*, *Euchrysops dolorosus* Trim.

On a *Vernonia* flower-head, and on *Vernonia* tree-trunks near by (site B), there were placed: *florella*, *niavius*, 2 *orithyia*, *cardui*, 2 *zeno*, *Parnara mathias* F., and one other *Parnara*. At another spot (C) the following insects were impaled on thorns of bushes close to the outskirts of the forest and on tree-trunks, or on the ground in between: *pylades*, *demodocus*, *florella*, *niavius*, *lobengula*, *safitza*, 3 *perspicua*, *agatha*, 2 *clelia*, 5 *cardui*, *Parnara borbonica* Bdv., 6 *hottentota*.

During the course of the experiment there were added to A: *Mylothris rüppelli* Koch, *florella*, *chrysippus*, *lobengula*, *ceryne*, 2 *cardui*, *johnstoni*, *Acraea cabira* Hpfr., *oncaea*.

Soon after the 'bait' at A had been laid down, and while Swynnerton was placing others, an unknown bird took the two *pylades*, hawking down, but failing to take, the *albimaculata*, which was nearly as large.

Regarding the *Pogonocichla*, Swynnerton said that they had enterprise enough to attack a large *demodocus* and were hungry enough to carry off a *chrysippus*, after which a *cardui* was selected by the same individual from several larger or more conspicuous butterflies (*rüppelli*, *florella*, *lobengula*, *oncaea*, *egina*), then another *cardui* (or *ceryne*), then *cardui*, this time neglecting, among others, the far larger and more conspicuous *demodocus* and *lobengula*. Later, one of the birds appeared hungry enough for the *lobengula*, which it took away, leaving the smaller skippers.

The Boubou shrike took *cardui* from among *albimaculata*, *safitza* and *cebreue*, but immediately afterwards carried off the *albimaculata*. Later, after ample inspection of a group including *niavius* and *egina*, he selected in turn two *cardui*, *florella*, *cardui*.

After addition of other butterflies to the bait, including *lobengula* and *oncaea*, he selected a small, rather dull specimen which could not be identified.

After the addition to the specimens in the ditch he selected *demodocus* (the largest present except *niavius*, which was still refused), then ate *rüppelli* and *cardui* from among the larger and conspicuous Danaididae and Acraeidae. Later, doubtless hungrier, he took the *niavius*. The next visit was to another group of bait, when he neglected *niavius* and two *cardui* but attacked in turn *florella* and *angolanus*.

A *Chlorophoneus* passing along examined the *Vernonia* panicles in vain but, detecting the *Neptis agatha* perched on a projecting broken branch, at once flew across, seized it, and went off with it.'

Regarding results to be deduced from this experiment, Swynnerton wrote: 'Without the key afforded by many hundreds of experiments on captive birds, the foregoing attacks [as noted in his minutely detailed account of the experiment] would convey little but a picture of apparent indiscriminateness.

As it is, knowing that the stage of repletion, including the emptiness of stomach produced by the ejection of an occasional pellet, will produce great variation in the acceptances of a bird; knowing also that the taking of a large butterfly in preference to smaller species means not that the latter were less liked, but that the bird was hungry enough for the former, we are able, taking each group of choices separately, to deduce some definite preferences.

For *Pogonochila* :—(1) *cardui*; (2) the larger and more conspicuous species present with it: *demodocus*, *rüppelli*, *florella*, *lobengula*, *oncaea*, *egina*. But, with sufficient appetite, not only *lobengula* but *chrysippus* was eaten.

For *Laniarius* :—a (1) *cardui*, *rüppelli*, *florella*; a (2) *niavius*, *oncaea*, *egina*. b (1) *angolanus* and *florella*; b (2) *niavius*. (a) and (b) represent separate appearances.

Experiment IV. Preferences shown by two stonechats.

Swynnerton placed the following specimens at the foot of a bird-post which he watched from the verandah;—*Nireus*, *medusa*, *chrysippus*, *albimaculata*, *agatha*, *dryope*, and the following 'skippers': *borbonica*, *detecta*, *hottentota*. [Numbers of skippers not stated, but at least six altogether.] On twigs springing from the top of the post he placed *nireus*, *demodocus*, *florella*, and a conspicuous day-flying Hypsid moth, *Argina leonina* Wlkr. The male stonechat arrived first: he settled on top of the post and thence darted down on one of the skippers—I could not be sure which—and crushed and swallowed it. Then, having stood considering for two or three seconds, he rushed forward at the *albimaculata*, which attracted him by a movement, seized it, and battered it well before throwing it away, then returned and ate a second skipper and picked up and flew right away with a third. Soon afterwards the hen came. She at once darted down on and ate the three remaining skippers, then, passing over the *chrysippus* and *medusa* (the former of which she obviously did see and the latter probably), came next on the *agatha*, which she at once picked up, crushed slightly, and swallowed, wings and all. She then flew off.

Some definite preferences seemed to have been shown in this experiment. Small dull skippers and *agatha* appeared definitely to be preferred by one or other stonechat to *medusa*, *chrysippus*, and *albimaculata*. Note that *medusa* is of about the same size as *agatha*, which was preferred to it, *chrysippus* and *albimaculata* being larger. The rejection of *albimaculata* by the cock which seized it is interesting. Swynnerton wrote; 'The *albimaculata* was nearly killed by the treatment it received, and died later. This I found interesting, as it is by no means uncommon for these butterflies to appear little the worse for having been tasted'. This observation may be compared with that of Neave on an *Acræa* which was seized by a wagtail and rejected, little damaged (Proc. Ent. Soc. Lond. 1912, lv).

Such toughness is, of course, extremely valuable to aposematic insects which, as it were, court investigation.

Experiment V. The following butterflies were placed on a thorny twig of *Solanum* beneath *Vernonia* flowers: *senegalensis*, *safitza*, *cebreu*, 2 *cardui*, *terpsichore*.

A bush-shrike (*Chlorophoneus*) approached the bait, and 'definitely' passing over the *Terias* and the *terpsichore*, picked out, crushed and swallowed a *cardui* and *safitza*. He then made a few captures of insects amongst the *Vernonia*-flowers close by and, returning to the butterflies, picked out and ate the *cebreu*: he then took up the remaining *cardui* with an air of disinclination and, after crushing it, waveringly dropped it. He then closely scrutinized the whole twig and evidently was untempted by the *Terias* and *terpsichore*, both of which were standing out very conspicuously with widely opened wings, for he passed on. Nearly an hour later (5 p.m.: insects now scarce on the flowers) he or his mate returned and, at once flying straight to the twig, quite evidently remembering it, picked off, crushed, and swallowed the *Terias*. He then picked off the *terpsichore* and flew with it into the hedge: I did not see whether it was eaten'.

The *Chlorophoneus* showed preferences as follows:—(1) *cardui*, *safitza*, *cebreu*; (2) *senegalensis* and *terpsichore*. The *senegalensis* and *terpsichore* were eaten when the bird was apparently hungrier.

Experiment VI. A number of butterflies were put down in the ditch in the late afternoon. *Laniarius* visited them. He seemed not very eager and, moving about amongst them, picked up and ate four or five I found that the following had disappeared from the ditch: *nireus*, *Papilio antheus* Cr., 2 *perspicua*, *Cataglyphis cloantho* Cr., *orithyia*, 4 *cardui*. It is possible that the bird, with his back to me, had swallowed one or two insects without my knowledge. The following remained in the ditch, lively and uneaten: a female *florella*, *brigitta*, 2 *chrysippus*, *niavius*, *lobengula*, *safitza*, *campina*, *clelia*, 4 *terpsichore*, *zeno*, *detecta*. Some of these had doubtless not been seen by the bird, including probably the 'skippers', but it was generally interesting that the *Papilios*, six out of seven *Nymphalids*, and two out of four *Satyrids* should have gone, and not a single *Danaid*, *Acraea* or *Pierid*, though these were much more conspicuous.'

Experiment VII. Some of the butterflies used in the previous experiment, impaled on thorns of twigs, remained at the close of the experiment and were subject to attention from birds the following day. These were as follows:—*nireus*, *pylades*, 2 male and one female *florella*, *perspicua*, *Precis octavia natalensis* Trim., *cardui*, *terpsichore*. 'The *Acraea terpsichore* remained intact, exactly as originally placed, but every one of the others had been attacked and removed from their thorns during the day. That birds were the culprits was evident from the fragmentary condition of some of the wings and the bill marks on others. In some instances the butterflies had disappeared, except for wing-fragments. In others they were lying much broken up on the ground below, having

evidently been found too dry to eat. It looked as though the *terpsichore* had escaped through being recognized and remembered as unpleasant than the species attacked.

Experiment VIII.—[The notes of this experiment are particularly difficult to analyse, and I found it impossible to obtain a clear idea of what was actually put down for the Bou-bou shrike to select. Accordingly the briefest possible notes of the bird's behaviour are given, followed by Swynnerton's opinion of its actual preferences.] The shrike came and went repeatedly to two 'placings' of butterflies which were reinforced during the course of the experiment.

First coming : (1) ate *florella* ; then (2) picked up, but quickly threw aside, some unrecognized butterfly ; (3) seized and battered a male *agathina*, but Swynnerton did not know if it was eaten.

The shrike then went into the ditch where Swynnerton had placed the following butterflies : *florella*, 2 *chrysippus*, *niavius*, *perspicua*, *clelia*, 2 *madagascariensis*, 2 *cardui*, *terpsichore*. The observer was busy over something else and did not see all that happened. 'When I did see him he had apparently just swallowed something : he then seized some butterfly and flew up into the hedge with it.' After the end of the experiment the only butterflies missing from the ditch were the two *cardui* and one *orithyia*.

Second coming : (1) picked up and ate *demodocus* ; (2) neglected *echerioides* beside it ; (3) took away a *dardanus*, female form *hippocoon*, the battered wings of which were subsequently found ; (4) went off to a *pylades* several feet away and ate it ; (5) returned to the *echerioides*, which was repeatedly battered, and abandoned and picked up again, finally abandoned ; (6) picked up and ate an unidentified butterfly.

Third coming : (1) again attacked and abandoned *echerioides* ; (2) picked out (but they were quite dry, and were subsequently rejected after being crushed) *perspicua*, *clelia* and *cardui* from among *severina*, *brigitta*, *lobengula* and *terpsichore* ; (3) seized and went off with *pylades*.

Fourth coming : (1) again attacked the *echerioides* and abandoned it ; (2) ate *agathina* ; (3) twice picked up and rejected a newly put down *echerioides* ; (4) looked at a female *agathina*, turned away, turned back, took and dropped it ; (5) ignored *severina*, *brigitta*, *niavius*, *lobengula*, *terpsichore* ; (6) seized a *florella* eagerly and went off with it.

Fifth coming : (1) returned to *echerioides* and tried it several times and then ate something else (possibly a *campina*), and then ate the *echerioides*, cleaning his bill after.

The following preferences were deduced by the observer :—

Firstly : (1) *florella*, then *agathina*, which was preferred to some dark, unidentified butterfly ; (2) *cardui* and probably *orithyia* ; next, *chrysippus*, *niavius*, *anemosa* (large and conspicuous species which the shrike must have seen and would have taken first had it been hungry enough). A yellow female *florella*, matching leaves, may not have been seen, and *terpsichore* is small.

Secondly, five minutes later, we have the order : (1) *demodocus*, *dardanus hippocoon*, *pylades* ; (2) *echerioides*.

Thirdly, (1) *pylades* (fresh, eaten) and *perspicua*, *clelia* and *cardui* (tried, but too dry) ; (2) *echerioides* (repeatedly tried and rejected), *severina*, *brigitta*, *lobengula*, *terpsichore* (refused at sight).

Fourthly, (1) *agatha* and yellow female *florella* (special eagerness) ; (2) *echerioides*, and *agathina* female (both tried and rejected), and the others listed in thirdly (2).

Experiment IX.—The Bou-bou shrike selected the following species from among others placed in the ditch by Swynnerton : a female *florella* 2 *clelia*, an *orithya*, and a *cardui*. The neglected species were *pylades*, *brigitta*, *regularis*, 2 *chrysippus*, 2 *lobengula*, *perspicua*, *campina*, *Crenis boisduvali* Wallgr., 2 *dryope*, *cebrene*, *elgiva*, 2 *terpsichore*, *esebria*, *anemosa*. Swynnerton remarks : 'It was very striking that, as usual when the bird was apparently less hungry, the Nymphalids and the *Catopsilia florella* had been selected from out of the conspicuous Danaids, *Terias* and *Acraea*.'

Experiment X.—The following butterflies were laid down in the ditch :—*demodocus* female, *echerioides* male, *mesentina*, 2 *brigitta*, *chrysippus*, *albinimaculata*, *campina*, *Salamis parhassus aethiops* Pal., *agatha*, *elgiva*, *cebrene*, *clelia*, *octavia* (dried), 3 *cardui*, *terpsichore*, *caldarena*, *natalica*, *oncaea*, *Cupido plinius* Fab. The two largest butterflies were *demodocus* and *parhassus*. The Bou-bou shrike started (1) by eating *demodocus*, (2) seized and took away *echerioides*, (3) ate two *cardui*, (4) seized and took away *parhassus*. 'Probably up to this time, no preferences had been shown, the shrike taking the largest insects as they came, or caught his eye. . . . Having filled up a good deal he returned and discriminated.'

The following probable orders of preference were noted :—(1) What appeared to be *cardui*, (2) *agatha*, which had been definitely tried and rejected. On a second visit (1) *florella*, (2) *pylades*, (3) *natalica* and *chrysippus*.'

Experiment XI.—Two placings of butterflies were made :—In the ditch were 4 *pylades*, a female *florella*, *brigitta*, 3 *chrysippus*, 2 *albinimaculata*, 2 *lobengula*, *niarius*, *Amauris o. ochlea* Bdv., 2 *campina*, 6 *perspicua*, *daedalus*, *Neptis swynnertoni* Trim., 2 *agatha*, 5 *Bylbia acheloia* Wallgr., *dryope*, *Precis terea elgiva*, Hew., *octavia*, 5 *cardui*, 2 female *oncaea*, *anemosa*, *natalica*, *rabbaiae*, *terpsichore*, *caldarena*. In the hedge were *Papilio leonidas* Fab., 2 male *echerioides*, 2 male *dardanus*, *florella*, *senegalensis*, *campina*, *perspicua*, *Crenis natalensis* Bdv., *agatha*, *dryope*, *acheloia*, *cardui*.

The Bou-bou shrike flew down into the ditch immediately and (1) hopped over *ochlea* to seize and eat *cardui*, (2) disregarded two *pylades* to eat a *florella* close to them, (3) after scanning the bait from a perch seized and ate *pylades*, with hesitation, and then went away : on return he neglected *pylades* and ate a *cardui*. After an interval he took the *pylades* and went off with it, came back to the butterflies and, after indecision, took eagerly a *florella* and ate it, returned and ate *natalensis*, inspected the other butterflies again, seized a *dardanus*, which moved, and took it away : returned and closely inspected various butterflies without finding any that suited until he saw a *leonidas* and pounced on it and swallowed it.

Swynnerton's comments on this interesting behaviour are: 'The Bou-bou commenced by displaying the following order of preference: (1) *cardui* and *florella*, (2) *pylades*, (3) *ochlea*, *niavius*, *chrysippus*. On return from absence he ate *pylades*; then chose as follows:—(1) *florella*, *natalensis*, *dardanus*, *leonidas*; (2) *echerioides* male, *senegalensis*, *chrysippus*, *ochlea*, *agatha*, *acheloia*.'

Experiment XII.—Swynnerton laid down the following butterflies in the ditch:—2 *pylades*, 2 male *echerioides*, *rüppelli*, *florella*, 3 *brigitta*, 2 *chrysippus*, *niavius*, *ochlea*, *albimaculata*, 2 *lobengula*, *campina*, 3 *perspicua candiope*, 2 *agatha*, *swynnertoni*, *daedalus*, 7 *acheloia*, *octavia natalensis*, 3 *cebrene*, *orithyia*, *terea*, 8 *cardui*, *cabira*, 3 *terpsichore*, *natalica*, 2 female *oncaea*, *Parnara* species, *zeno*, and an aposematic day-flying Geometrid moth, *Aletis monteironis* Druce.

The experimenter was away for a time and on return found the Bou-bou shrike already in the ditch moving quietly about among the butterflies: the following were now missing; *florella*, 1 *pylades*, *daedalus*, and had presumably been eaten. The shrike now picked out and ate (1) 4 *cardui*, ignoring (2) *echerioides*, *pylades*, several *acheloia*, *chrysippus*, *natalica* and the *Aletis*, all of which were moving about and fluttering; (3) suddenly caught sight of *candiope*, dashed at it with utmost eagerness, and took it off into the hedge, where he spent a considerable time, and then returned to a perch on the hedge overhanging the butterflies and, after scanning them well, took no more notice. While the bird was away the observer had added to the bait *Papilio porthaon* Hew., 2 *pylades*, *rüppelli*, a female *agathina*, two male and a female *florella*, *brigitta*, *ochlea*, *campina*, 4 *perspicua*, *acheloia*, *elgiva*, *Precis antilope* Feisth., 4 *orithyia*, 4 *cardui*, *cabira*, *Platylesches moritili* Wallgr. After a while the shrike roused itself and took (4) a *Precis* (*terea* or *orithyia*), (5) an *orithyia* after inspection from above, (6) *florella*. After an interval it took (7) *echerioides* male, which was finally eaten after indecisive preliminary crushing, swallowing, and bringing up again, (8) *cardui*, which was eagerly seized and swallowed after inspection, (9) passed over a male *echerioides* and *terpsichore* and picked up *mesentina*, crushed and rejected it, and flew off.

Swynnerton commented on this experiment that it was evident that *cardui* was preferred to *pylades*, *echerioides*, *agathina*, *rüppelli*, *swynnertoni*, *acheloia*, and the Danaiids and Acraeids, which were conspicuous and were actually passed over by the shrike in his search for *cardui*. The *candiope* was even more enthusiastically eaten than *cardui*. The waiting until the condition of the bird's stomach was such that it was ready to eat *echerioides* is also noteworthy. Preferences were as follows:—(1) *candiope*, (2) *cardui*, *terea* or *orithyia* and *florella*, (3) male *echerioides*, *mesentina* and probably *pylades*, (4) Danaiids, Acraeids and *acheloia*, the *Aletis* moth, and the *Mylothris*.

Experiment XIII.—The following were laid down in the ditch:—Male *echerioides*, 2 *pylades*, *porthaon*, 3 *rüppelli*, *florella*, *brigitta*, 2 *chrysippus*, *niavius*, 2 *ochlea*, *albimaculata*, 2 *lobengula*, *campina*, 3 *perspicua*, 2 *agatha*, *swynnertoni*, 7 *acheloia*, *terea*, *antilope*, *octavia sesamus* (dry-season form), *cabira*, 2 *terpsichore*, *natalica*, *oncaea*, 2 *caldarena*, *detecta*, *Aletis monteironis*.

The Bou-bou shrike, moving among the butterflies, picked out and ate in turn, wings and all, *pylades* and two male *florella*: picked up and rejected some smaller species (! *cardui* or a *Precis*), ate a female *florella* and carried off a second *pylades*.

Swynnerton remarked that it is probable that *pylades* and *florella* were preferred to other butterflies as large as themselves such as *echerioides* and *porthaon*, and the Danaines *chrysippus*, *niavius*, *ochlea*, *albimaculata* and *lobengula*.

Experiment XIV.—The following butterflies were placed in the ditch :—*echerioides* female (mimic of *Amauris*), 3 *rüppelli*, 6 *brigitta*, *regularis*, 21 *campina*, *sufilza*, 2 *perspicua*, a species of *Ypthima*, *Neptis saclara marpessa* Hpf. *agatha*, 7 *acheloia*, 2 *elgiva*.

In the hedge were the following :—*echerioides* male, *brigitta*, 23 *campina*, *perspicua*, *agatha*, 4 *acheloia*, *dryope*, *octavia*, *natalensis*, *Precis archesia* Cr.

The Bou-bou shrike appeared after half an hour and (1) ate a *campina* that had wandered away from the rest, (2) passed by *echerioides* female, (3) picked out two *acheloia*, *terea*, an *agatha* and two more *campina*, (4) snapped at but did not pick up a *campina* (or *perspicua*), (5) dashed at *terea* with enthusiasm and swallowed it, (6) picked up and rejected two *campina*, (7) after looking about picked up and ate slowly 4 *campina* (or *perspicua*), (8) flew off, (9) reappeared after twenty minutes and scrutinized the butterflies for a minute, (10) dashed down on *agatha* and swallowed it, (11) looked around, picked up the mimetic *echerioides* (which had not opened its wings) and flew off with it, (12) reappeared at the hedge collection of butterflies, to which 2 *lobengula* had been added, (13) after long scrutiny seized quietly by the fore wings the *octavia*, which had wandered off to hide in a dark corner, and ate it, (14) ate a *campina* and then six more *campina* in succession and flew away.

Swynnerton deduced the following preferences :—(1) *terea*; (2) *campina*, *agatha*, *acheloia*; (3) on reappearance (1) *agatha*, *octavia* and *campina*, *lobengula* and male *echerioides*. The *terea* was eaten with greater enthusiasm than the three next cited, but without doubt all these were liked better than *brigitta* or *regularis* and *rüppelli*, none of which the bird troubled to try at all, though they were extremely conspicuous.

Experiment XV.—The following butterflies were placed in the ditch :—2 *rüppelli*, 7 *brigitta*, 6 *chrysippus*, 2 *niavius*, 2 *ochlea*, 2 *lobengula*, 10 *terpsichore*, 2 *natalica*, 8 *caldarena*, 4 *asema*. [All, it will be noticed, are of aposematic coloration and presumably distasteful, except *brigitta*.]

The Bou-bou shrike arrived, perched above the bait and inspected it, then dropped to the ground and moved along it—(1) passing through, and ignoring, two lively *chrysippus* and one *ochlea*; (2) arriving at the main group he picked out and ate *lobengula*, 'doubtless the largest butterfly present that he felt hungry enough to eat; (3) looking well about him, moved into the *Acraea* group, picked out and ate the larger of two *natalica*; (4) at once flew off.

Swynnerton remarked that the bird showed no disposition for *brigitta* or *rüppelli* or anything except the two actually eaten. This confirmed the conclusion drawn by Swynnerton from his previous experiments with captive birds that *lobengula* and *natalica* are less unpleasant than *chrysippus*, *niavius* or *ochlea*.

Experiment XVI.—Swynnerton had just gathered up butterflies remaining from a previous experiment when the Bou-bou shrike 'suddenly appeared in the hedge'. The butterflies, as follows, were thrown down without any attempt at arrangement—many of them, especially the small, *brigitta*, being rather dry: 4 *brigitta*, 3 *chrysippus*, 2 *terpsichore*, *natalica*, 2 *caldarena*, *asema*. The shrike approached along the ground and (1) picked up the *asema* hesitatingly, dropped it, and picked it up again; (2) suddenly seeing a *brigitta* he threw down the *asema* and swallowed the *brigitta*; (3) searched among the butterflies and picked out all the three remaining *brigitta* but, apparently finding them too dry, after crushing them, he abandoned them; (4) moved about in the ditch, apparently swallowing minute insects; (5) crushed the rejected *asema* and rejected it again (6) in favour of a *brigitta* which he found too dry and abandoned for (7), another *brigitta* close by, which he battered and abandoned, (8) returning to the *asema*, which he crushed, dropped, picked up again and swallowed, and (9) flew off. When the remaining butterflies were counted it was found that a *terpsichore* and a *brigitta* had apparently also been eaten. Swynnerton remarked that the experiment showed clearly that *brigitta* was preferred to *asema* and the latter, probably, to *caldarena*, *natalica* and *chrysippus*.

Experiment XVII.—The notes on this experiment, and the following, are very long, but extracts are taken as there is some evidence for the reality of mimicry of *Acraea zetes acara* Hew. by *Pseudacraea boisduvali trimeni* Btlr. The Bou-bou shrike 'came out from the hedge on to a perch in front of which I had placed a *boisduvali* and a *dardanushippocoon*: he reached forward and took the former. He commenced pulling at the insect not over enthusiastically, and suddenly changed his manner to that of one who has unexpectedly found a treasure—a change of manner from lethargy to energy that I knew well, having frequently seen it in cages. The shrike battered and crushed the *boisduvali* and then started off down the hedge with it in his most sprightly and triumphant manner: he was afterwards seen battering it against a stump.' [Although Swynnerton did not see the *Pseudacraea* eaten, he found afterwards one fore wing lying on the ground and no trace of the body.]

Experiment XVIII.—Next day a large number of butterflies were laid down in the ditch, including a 'large bright male *Acraea zetes acara* Hew., killed and placed with expanded wings exactly where the *boisduvali* had been yesterday'. The Bou-bou shrike, after selecting and carrying away certain butterflies, 'once more came to the edge of the bank and thence inspected the butterflies, but, apparently finding nothing to please him, proceeded to move up towards the other placing of butterflies. Arrived there, he looked at them, then, passing directly over the *zetes*, and ignoring an *asema* that had climbed a little way up a stem immediately before him, he picked up, with an appearance of some little disinclination, an *antheus*, battered it a little and then tossed it aside in favour of a yellow female *florella*, which, after an unenthusiastic crushing, he finally abandoned. He then returned to the *antheus*, battered off its wings and swallowed it, and returned to another female *florella*. This he picked up with disinclination, crushed well and dropped, again picked up, crushed and dropped, and so on, evidently wavering as to whether to eat it. The third time

it was abandoned altogether and the shrike looked carefully round him, picked up with absolute disinclination a *campina* and dropped it, did the same to a second, completely ignored the *asema* which, with slow flapping, was climbing up a stem within easy reach, but, turning half round, looked at the *zetes*, picked it up, crushed and dropped it, looked closely at it again (was he hoping it was *boisduruli* again !), and once more picked it up and crushed it, this time abandoning it completely. . . .

Swynnerton remarked on this observation : 'The bird's repeated trial of *zetes* when he had just refused *asema* and was not hungry enough to eat even *campina*, was striking. It seemed possible that it was due to the hope that the butterfly might prove to be a pleasanter species with the same appearance, for he ate the mimetic *boisduruli* only yesterday.'

Experiment XIX.—The following butterflies were put in the ditch :—Male *dardanus*, 2 *dardanus hippocoon*, male *echeroides*, 2 *nireus*, 2 *demodocus*, 4 *pylades*, *leonidas*, male *argia*, 3 males and a female *florella*, 3 *senegalensis*, 4 *Terias desjardinsi regularis* Btlr., 6 *brigitta*, 6 *chrysippus*, 2 *niarius*, *lobengula*, 15 *campina*, *perspicua*, 4 *agatha*, 3 *acheloia*, *Hypolimnas dubia wahlbergi* Walgr., *archesia* (dry-season form), *octavia* (dry form), *cardui*, *johnstoni*, *cabira*, 2 *terpsichore*, 6 *natalica*, 6 *asema*, *anemosa*. Also three large larval grasshoppers of a kind known to be liked as food.

The Bou-bou shrike, on arrival at the ditch, (1) at once detected and ate a grasshopper, (2) ignored *chrysippus*, (3) ate two more grasshoppers with lessening appetite, (4) passed by *nireus*, *demodocus*, *pylades*, *leonidas*, *florella*, *campina*, *dubia*, *octavia*, (5) after slight delay ate another grasshopper, (6) picked up another grasshopper and took it into the hedge, (7) after half an hour returned and took two *demodocus* into the hedge, (8) quickly came back, looked about him in the ditch, and ate a *cardui*, (9) took male *florella* into hedge, (10) remained motionless in hedge, ignoring a *chrysippus* that had climbed the bank, a flying *campina* and a flying *nireus*, (11) dropped down to bank, ignoring a conspicuous *natalica*, (12) seized and took away *pylades* from alongside a *dubia*, (13) found and ate something in the hedge, (14) took into the hedge, and ate, a *nireus*, (15) came back to bank, inspected the insects, but went back to hedge, having taken nothing more. Swynnerton now added to the bait 2 *nireus*, 2 *Precis* (species not mentioned, but a dry-season form). The shrike (16) returned to the ditch, scrutinized the insects for a long while, then deliberately picked out *cardui* and flew off with it ; (17) on return looked around, avoided the *dubia* which fluttered up against him and, darting to the ditch, picked out what seemed to be a *cardui* and took it into the hedge, (18) returned, picked out, and ate, another *cardui*, (19) returned to the bank, ignored three fluttering *cardui* and a small *Lycænid* and a *nireus* which flew down into the ditch, (20) dashed forward with great eagerness to a disabled *pollux* which Swynnerton had thrown into the ditch, but, although obviously very eager for it, was afraid of coming nearer to the observer and drew back ; (21) finally took a *florella* and flew off with it into the hedge.

The following preferences were deduced by Swynnerton :—(1) *pollux* and the grasshoppers, (2) *cardui*, (3) *florella* and probably *nireus*, (4)

pylades and *campina*, (5) *chrysippus* and *natalica*, and with them the *Terias* spp., *Amauris* spp., *agatha*, *Acraea* spp. The mimetic *dubia* was persistently ignored.

Experiment XX.—The following were laid down in the ditch :—*dardanus hippocoon*, 5 male and 3 female *echeroides*, *medusa*, 2 *senegalensis*, *brigitta*, 9 *chrysippus*, 7 *niavius*, *ochlea*, 2 *lobengula*, *dubia*, *esebria*, *johnstoni*, *terpsichore*, *natalica*, 2 *asema*.

The Bou-bou shrike went down into the ditch and (1) took away a large butterfly, not clearly seen, which might have been *chrysippus*; (2) returned and, after looking at two *chrysippus* and a male *echeroides*, carried off the latter; (3) on return, after a little hesitation, chose the largest butterfly present, a fine *niavius*; (4) returned a quarter of an hour later and took *asema*; (5) then made a careful scrutiny of the butterflies in the ditch—male and female *echeroides*, several *chrysippus* and *niavius*, a *dardanus hippocoon* with wings outspread and the *dubia*. The bird flew straight across to the *hippocoon*, unhesitatingly picked it out from *niavius* and *dubia* close beside it, took it to the hedge, and ate it; (6) came straight back to the bank just over some of the butterflies and, after a good inspection, dropped down beside the three male *echeroides*, which, as well as *niavius*, he quite ignored; (7) looked searchingly at the *dubia*, which fluttered, and at a *niavius* close by, and picked up a spread-out female *echeroides*, at once dropping it; (8) turned to the male *echeroides*, selected a large one and flew off with it.

Swynnerton remarked on this experiment: 'I regarded this as a further and more definite triumph for the *dubia*. Its very convincing likeness to *niavius* had stood well the severest test to which it could have been subjected. The less perfect resemblance of the *hippocoon* to the same model failed to protect it, whatever it might have done had the bird had less leisure for examination.'

Experiment XXI.—The following butterflies were put in the ditch :—3 male *dardanus*, 2 male *echeroides*, 3 *nireus*, 4 *pylades*, 2 *agathina*, *regularis*, 2 *chrysippus*, *niavius*, 28 *campina*, 2 *agathu*, 2 *acheloia*, *cardui*, *natalica*. The Bou-bou shrike, when it came, (1) glanced at and passed by a *chrysippus* and other butterflies such as *agathina*, *regularis*, *niavius* and *natalica*; (2) at once picked up and swallowed a *campina*, (3) took an *angolanus* into the hedge, (4) returned past *chrysippus*, looked at it hesitatingly, picked it up and dropped it, (5) took and ate another *pylades*, (6) ignored another *pylades* next it, (7) ate two *campina*, (8) looked hesitatingly at *niavius*, as he had done at *chrysippus*, then carried it into the hedge and remained out of sight longer than was necessary to eat it, (9) came back and sat high in the hedge and remained motionless, (10) flew back to the spot to which he had taken *niavius* but came back in a few seconds to the following group of butterflies: *nireus*, several *campina*, *daedalus* (dead and dying), *natalensis*, *parhassus*, *cebrene*, *clelia*, *orithyia*, *natalica*. One *campina* fluttered away and the shrike chased it, and (11) checked himself and picked out and ate in succession three *Precis*, (12) while eating the last he was practically touching the *parhassus* and, having finished eating, he glanced round and, having seized the *parhassus*, took it into the hedge,

(13) remained on the hedge motionless 'quite a long time', then went down and picked out a *chrysippus*, which he dropped, (14) went straight for *nireus* (passing *agathina*, *campina*, and *natalica*), and took it to the hedge, where he had taken *niarius*: (15) after ten minutes reappeared and ate *campina*, (16) ate *cebreus*, (17) ate two more *campina*, (18) picked out from among *campina* a *Precis* (*clelia* or *orithyia*), which he ate (19), picked up a dead *dardalus* but, after several trials, dropped it—it was dry, (20) looked about and saw a second *parhassus*, darted at it and seized it with an eagerness approaching that for *Charaxes*, and took it into the hedge. (21) While the bird was away Swynnerton added the following butterflies to the previous bait:—Male *echerioides*, *nireus*, *demodocus*, *Papilio polixenes* Cr., *florella*, four *campina*, *cebreus*. After half an hour the shrike came out from the hedge, ignored the *campina* and darted at the *demodocus*, which was carried off into the hedge: (22) on the shrike reappearing, Swynnerton threw towards the other butterflies a *florella*, which the shrike chased and snapped at several times, breaking part of the wing before he secured the butterfly, and carried it off. On examination of the spot to which *niarius* (8) and *nireus* (14) had been taken, Swynnerton found the wings of the former on the ground on top of the wings of the latter. He wrote: 'It seems certain that the *niarius* was not eaten till after *nireus*. I have had many instances in which *Lanius* has impaled, for further use, very low-grade but large insects and eaten them after ejecting his next pellet. Also, as seen here, there is abundant evidence that at that stage the lowest-grade insects may be not merely tolerable but highly acceptable, especially if they are large.'

The following preferences were deduced from this experiment:—(1) *Precis orithyia* and *clelia*, (2) *Mycalesis campina* and *Papilio pylades*, (3) *Danaus chrysippus*, *Acraea natalica* and *A. asema*, *Mylothris agathina* and *Terias regularis*—all conspicuous and inspected, probably noted and refused.

Experiment XXII.—The following butterflies were laid down in the ditch:—2 male *dardanus*, 2 male *echerioides*, *pylades*, *nireus*, 2 *medusa*, male *florella*, 5 *Terias* of three species, *albimaculata*, *lobengula* (freshly killed and opened out), 40 or 50 *campina*, *perspicua*, 3 *agatha*, *natalensis*, *esebria*, 4 *natalica*, 2 *asema*.

The Bou-bou shrike soon appeared and very quickly (1) seized and carried off two large butterflies which were later found to have been *dardanus* and *pylades*, (2) picked up *nireus* and took it to the hedge, (3) carried off *pylades*. The two large and conspicuous *albimaculata* and *lobengula* were ignored.

This concludes the extracts from the MSS. left by Swynnerton. There was no summary, and the present writer therefore suggested to the Council of the Linnean Society that Swynnerton's summary of an early paper might very aptly be reprinted as a sequel to the present notes. The necessary permission having been obtained, the following summary is taken from Swynnerton's paper "Birds in relation to their prey: experiments on Wood-hoopoes, small Hornbills, and a Babbler," in the Journal of the South African Ornithologists' Union for December, 1915, pp. 91-109.

[Reprinted from the 'Journal of the South African Ornithologists' Union',
Dec. 1915, pp. 91-109.]

CONCLUDING DISCUSSION.

We are perhaps inclined to take somewhat too much for granted a bird's relations to its prey. We shoot, say, a Puff-back Shrike and find in its stomach two wasps, the fragments of a Coprid beetle, and a *Precis* butterfly. We record the bare fact in our next paper, but otherwise think no more about it. Yet it would be most interesting to enquire whether the above insects represent its normal food or were only eaten under temporary stress of hunger: to know just *how* that Puff-back Shrike went about to circumvent the stings of the wasps, to break up the hard chitin of the beetle, and to capture so wary a butterfly: and whether other species of birds do these things in the same way or by other methods. It would be interesting, also, to notice that neither the wasps, the Coprid, nor the butterfly were about in large numbers, yet insects that *were* abundant were not represented in the bird's stomach. Why? And, if we decide that there must be some repugnance to, or fear of, or inability to catch or deal with, these more obvious insects, in virtue of what limitations on the bird's part does it exist, and how did the bird learn to avoid them? And so on.

Methods of attack.—That some species of prey have special defences that other species lack will hardly be denied, and it is open to a bird to deal with them (1) by employing special methods of overcoming the defence in question, or (2) by avoiding its possessor and exhibiting a preference for insects that are not thus defended. Actually, both things are done, and in the majority of cases it will depend on the bird's state of hunger which course will be chosen. A bird that is nearer repletion will not trouble to break up a dung-beetle or attack a wasp—however delightful it may be to eat it, if someone else will do it for him!—will often, when a little hungrier attack, with the greatest energy and skill; and the methods of attack that different birds apply to the different defences are of the greatest interest. Some received illustration in the experiments I have described above.

Take stings. The Babbler showed how completely helpless a powerful; wasp may be against even a weak-billed bird that has once got it on the ground. Attack after attack was piled in, giving no time for recovery; yet each attack was crisp and brief, so that no opportunity of using the sting was given. Bulbuls (*Pycnonotus*) attacked similarly, as would, no doubt, any of the birds—as *Telephonus*—that habitually batter their prey on the ground, or, being willing to attack wasps, are, nevertheless, too weak in the bill to do so with any success aerially. Stronger and longer billed birds attack the wasp they are hungry enough for when and where they can get it, but seize by the thorax and pinch as they seize. If the pinch fails—that is, if the thorax is not at once crushed—they let go again, unless the insect has so short a reach that they have nothing to fear from the sting. If, on the other hand, the pinch succeeds, the bird throws off all caution, at once either swallows the prey or brings into operation his usual methods for reducing any insect to an edible condition. I have already described (Journ. S. A. O. U., Dec. 1913, p. 97) the quite similar methods employed against a large snake by Ground-Hornbills—the attacks directed exclusively at the head, the latter's immediate

release every time the 'pinch' failed, and the abandonment of caution directly the head crunched.

The Babbler's methods as against hardness and gloss were in no degree less interesting. The bird, 'with head drawn right back and neck well arched', would strike 'blow after blow with terrific force for so small a bird' at the prostrate insect. It would steady it, if necessary, by holding it firmly in one foot while it struck the blows, as a man sometimes does with his hand a stone he is shaping. It would often, in the case of a slippery insect, strike with mandibles somewhat open, and thus partly arrest the prey's tendency to glance away. And it realized that the underside of the abdomen was the most vulnerable spot, for it specially turned the insect on to its back before commencing to hammer. That the method was a highly effective one is shown by the fact that the Babbler succeeded in breaking into and partly extracting the contents of a large hard flower-beetle that not only my Bulbuls, but a Roller (*Coracias garrulus*), failed to negotiate, and that my most powerful batterer of all, a Kingfisher (*Halcyon cyanoleucus*), took twenty minutes to make any impression on. My Shrike (*L. collaris humeralis*) experienced the very greatest difficulty with one, but finally, holding the beetle in one foot and tearing at the underside of the abdomen with its bill, it succeeded in doing just what the Babbler did: it extracted the contents of the abdomen but failed with the thorax. With the Coprid of experiment 555 the Babbler failed in good company—the Roller, the Bulbul, and the Shrike. The Kingfisher's 'first five smashing blows' (the beetle being held in its bill and struck against a branch) 'produced, I noticed, no result, but a few blows later the chitin of the thorax cracked right across'. As for the weevils of experiment 565, *all* the above birds failed with the harder species, whether batterers, hammerers, crushers, or tearers, but a Swempi (*Francolinus coqui*) just swallowed it. Even the Swempi, however, had difficulty with a yet larger weevil (*Brachycerus congestus* of 567) owing to its holding its very toughly attached legs straight out together instead of keeping them tucked in like a dung-beetle. The Kingfisher too, succeeded only with the *Anachalcos*, and it was the Kingfisher alone that successfully dealt with the gloss and torpedo-shape of the Buprestid beetle of experiment 568. But the Babbler's methods were once more vindicated when she broke up two Tenebrionid beetles of a species that the Roller tried for a few seconds to crush 'through sheer bill-pressure', but, failing, threw away. The Shrike failed, too.

Finally, the attack on the water-bug was most interesting, the Babbler's full methods as against hardness being brought into play here as against leatheriness. Its failure was again in good company. The Shrike failed to damage the bug, the Roller 'crushed it in every conceivable position', and, the insect at once resuming its former shape each time the pressure was relaxed and its claspers seizing everything within reach and jerking it repeatedly from the bird's bill, 'at last flung it away in a rage'. The Kingfisher swallowed it, but even *his* preliminary battering had failed to open a way for the digestive fluids to enter, and the bug was brought up in the next pellet quite undigested.

The methods of attack I have dealt with include methods of reduction (to an edible state). Some birds commonly forego these preliminaries.

A Francolin or Guinea-fowl will swallow the hardest of prey—*Brachycerus*, for instance, which I have taken from their crops—intact, and leave the muscle of the latter to do the rest. Other birds, as Kingfishers and Rollers, quite roughly break up the chitin by battering against a branch or crushing with the bill and then swallow whole. Most Picarians, in my experience, swallow whole, as do Swallows and a few other Passerines. Many Passerines, on the other hand (and some Picarians), prepare their food more thoroughly, 'pulping' the parts eaten, and going to some trouble to remove superfluous chitinous parts that may be an obstacle to swallowing. Shrikes of the genus *Lanius*, Paradise Flycatchers, Weavers, and Whydahs, and numerous other birds, hold the insect firmly in one foot, the tarsus resting on the branch, and tear or lever off the undesired parts (which commonly include the wings of butterflies) with the point of the bill. My Wood-Hoopoes were adepts at this. The 'batterers', on the other hand, which include Bulbuls, some Bush-Shrikes, and a number of other birds, seize the part they desire to remove and batter the insect against the ground or a branch till the part comes off. 'Snipping' is rare. The Wood-Hoopoes attempted it, sometimes unsuccessfully as regards the removal of the wings, but successfully in removing an abdomen from a thorax. Mr. G. A. K. Marshall, however (Trans. Ent. Soc. 1909, p. 339), refers to the interesting fact that certain Indian Bee-eaters 'cut-off' the wings of butterflies, while African Bee-eaters swallow these insects whole. *Merops viridis* and *M. leschenaulti* are apparently the Indian species specially referred to, and W. Davison ('Stray Feathers', vi. 1878, p. 68) is quoted with regard to the latter:—'. . . You hear a little click of the bill, and, as the bird flies off, the pair of wings come slowly fluttering to the ground.' It must be a very neat performance. The wild Bee-eaters of my own observations (I have seen more than a hundred attacks on butterflies by wild *M. apiaster* and a few by *M. persicus*, *Mel. bullockoides*, and *M. meridionalis*) have always swallowed their prey whole, and my tame European Bee-eater always did the same, merely crushing it first. *Lophoceros* of these experiments was also a 'swallower', but not quite a typical one; for, owing, I suppose, to the length of its bill and the shortness of its tongue, it had, in order to swallow, to throw the prey back from the tip of its bill straight into its throat. The same applies to *Bucorax*, and I have already ('The Ibis', 1908, p. 407) described the very wasteful swallowing of figs in the same way by *Bycanistes*.

One of the neatest actions that I have witnessed on the part of a bird was the capture of the *Charaxes* by the Babbler in experiment 553. It darted out its foot as the butterfly glanced past, and, seizing it most skilfully in its claws, pinned it thereby to the ground. The method is one that is more likely to have been employed in the bird's wild state in relation to grasshoppers and fast-running ground-beetles than to butterflies. That the rather larger butterflies are well protected against birds by their broad expanse of wing was well illustrated in what preceded the above capture. That such tough butterflies as the largest species of *Charaxes* are additionally well protected against such relatively weak and small-billed birds as *Crateropus* was well shown by what followed that capture, as also by difficulties of the same kind experienced by my Bulbuls, *Pycnonotus* and *Phyllastrephus*. The two points together tempt

one to a brief discussion of the attitude of birds to butterflies. That they do attack them, and that very largely, I am convinced through having myself witnessed in the field many hundreds of attacks by very various (and in some cases very unlikely) birds in a single very circumscribed locality, and through having seen damage of a kind that one sometimes finds in the wings of nearly every high-grade butterfly being actually inflicted by birds both wild and tame. At the same time the pleasanter butterflies are possessed of great wariness and a difficult flight, while the brittle wing ever interposed between themselves and an enemy must frequently provide the latter with disappointment. So that, as Marshall long ago suggested, it is probable that the average small bird not possessed of the extreme skill in aerial capture that characterizes Bee-eaters, Swallows, Drongos, and some Flycatchers will probably make most of his attacks on butterflies when he finds them resting, engaged in some absorbing occupation, passing quite close to his perch, or for some other reason in or beside cover. This, and the fact that butterflies go to ground and stay there when at all systematically attacked by birds, probably, with lack of special observation, accounts for so few attacks on them being ordinarily witnessed. The facts bearing on the subject that figured in the experiments described above were (1) the really very excellent knowledge of his butterflies shown by adult *Lophoceros melanoleucus* on entering captivity, the probable previous knowledge shown in *Irrisor's* initial treatment of the highly nauseous butterflies *Danaida chrysippus* and *Acraea acara*, and that displayed by another bird of the same species; (2) the evidence touching the question, 'Does the necessity for removing or swallowing the stiff, strongly-attached wings act as a deterrent to attack on butterflies?' On the strength of experiment 503 (on *Irrisor*) I decided that, 'while wings hampered the birds, they failed to deter'. On the whole, however, a relatively replete bird *is*, I think, slightly deterred, just as he does not then care greatly to attack such beetles, wasps, and grasshoppers as tend to give him a little trouble. The treatment of *P. demodocus* supports this view.

The only method of *search* that was illustrated in the above experiments consisted in the probing of all the cracks of their cage by the Wood-Hoopoes with their long thin bills. Many of the methods by which birds obtain their prey are not readily capable of illustration by caged individuals. Such are the extraordinarily minute search of bark and twigs and leaves and ground by Warblers, Tits, Creepers, *Phyllastrephus*, and so many others of our small birds; their trials of inanimate objects, based doubtless on past experience of twig-, bark-, and excrement-resembling larvae, leaf-resembling butterflies, and lichen-like moths* (*Lophoceros melanoleucus*, however, tried a lump of mingled earth and excrement); the great mixed hunting-parties, in which birds of numerous and very diverse species join to 'drive' the woodlands; the attendance on these parties of Drongos and Flycatchers; attendance on driver-ants, on grass-fires, on flocks of seed-eating birds, and even on man and monkeys, for what they may flush; the sharp sight that enables Swallows and Kites

* Both facts have a bearing on the argument that such resemblances constitute hypertely.

instantaneously to pick out from amongst masses of ash and unacceptable objects racing upwards in the smoke and wind of a grass-fire just such insects as are acceptable to them; the methods by which insectivorous birds circumvent winged and wary prey—the furtive approach, culminating in a sudden quiet nip, of a *Telephonus* or a *Dryoscopus guttatus*, the short, sharp attack on an insect flying past of the average small bird, the longer-range attacks and bolder pursuits of a Drongo or Paradise Fly-catcher, the yet bolder and more graceful work of Bee-eaters, Swallows, and Kites, the headlong drop after an insect that falls, and the ensuing search should it reach the ground, the flying wing-fragments, the marvellous twistings and doublings, the empty bill-snappings that characterize the headlong fall should the insect be a butterfly, the mid-air struggle to hold a *Charaxes* imperfectly caught, and the rush to the spot of the bird's companions on his losing his exclusive right to the insect through its escape from his bill. None of these things are readily illustrated by birds in captivity, but all should be mentioned in any discussion of the relations of birds to their prey. The one thing that *was* illustrated above was the normal response of a butterfly to attack. *Eurytela hiarbas* 'took cover' and stayed there, using the projecting rim of a saucer as in nature it would have used a leaf.

We have now, so to speak, discussed how our hypothetical Puff-back Shrike slew his wasps, reduced his beetle, and captured his very wary butterfly. We have yet to consider why, out of vastly more abundant species that were present at the time, he should have chosen to eat these three. We have to discuss, in other words, his digestive limitations and how he came to realize them.

The existence of nauseating qualities in certain prey was well attested by certain incidents in the experiments on the Wood-Hoopoes. A, the wisest of them, was over-persuaded by myself and ate a *Danaida* and an *Acraea acara*. C followed suit with a *Danaida*. B ate only the abdomen of a *Danaida*. Even B became fairly miserable. The other two were completely nauseated, and, after much straining, vomited up all that they had eaten of the offending butterflies. C was similarly nauseated by an *Amauris*. But many other butterflies were eaten without the slightest apparent ill-effects. Here we at once have an opening for such preference as we suppose our Shrike to have shown. A similar contrast in after-effects is to be found in every insect order, and a similar inability to eat low-grade insects without nausea beyond a certain point in the process of repletion has been evinced by numerous species of birds beside Wood-Hoopoes. Even *Lophoceros leucomelas* A showed great uneasiness after having eaten the brilliant strong-smelling moth-larva of experiment 520, and refused another with anger; and again apparently somewhat overstepped the safety-limit in experiment 521 and, probably, 526. These instances were in relation to *Acraea*. B did the same in relation to *Amauris*. Whether her eating of earth after her *Danaidas* indicated a similar condition it is not easy to say.

It is a curious fact, nevertheless, that even those birds with the smallest capacity for eating nauseous insects are able to eat one or two with apparent impunity, and even eagerness, when their stomachs are empty and appetite good. Thus the average bird may quite readily eat *Danainae*

or Acraeinae several times in the day—in the early morning or after some other long interruption to feeding and after the ejection of each pellet. As it fills up somewhat, it rejects such very low-grade prey, but eats other species, some of which, in turn, it finally rejects when slightly fuller, though still eating the others. And so, through the successive elimination of many grades, right up to repletion-point. The main difference between *Lophoceros* (and *Bucorax*) and the more normal birds I have experimented on is that the Hornbills are able to accept and digest such insects as *Danaida* and *Acraea* in larger numbers and up to a far later stage in the filling of their stomachs. Once, however, they reach the point at which such insects become unacceptable, their preferences follow the course of most other birds. First the Danainae are discarded, then the Acraeinae, then *Mylothris*, then *Belenois*, *Terias*, and some Lycaenids, then *Mycalasis*, *Neptis*, a skipper or two, and various mimetic genera in Nymphalinae, Pierinae, and Lycaenidae, then *Eurytela* and *Leuceronia*, next certain Papilios, and after them *Precis*, etc. Finally (if the bird is capable of easily swallowing or reducing it), *Charaxes*: also some skippers. These would in most cases be eaten nearly to repletion-point, but the average bird will still find room for one or two such Noctuids as the *Sphingomorpha* of the above experiments, while in birds that specialize in some one order—as a Drongo in Diptera—several grades of that order will often still intervene between the rejection of the pleasantest insects of the remaining orders (including, it may be, butterflies) and actual repletion-point.

As well as these more general 'specialists' and birds—such as Hornbills—that are indiscriminating up to (but not beyond) a certain point, we have yet another class—the specialists in some one family or sub-family of highly nauseous insects. I believe that our common Bulbul (*Pycnonotus layardi*) is to some extent specialized to digest Danaines, the individuals on which I have best tested them placing them as high as *Mycalasis*; and it seems probable that the Ashy Wood-Swallow of India (*Artamus fuscus*) is even further specialized in the same direction*. That this specialization of the digestion in a particular direction (if I am right in believing it to be present) has perhaps been accompanied by loss of power in another direction is suggested by the fact that my Bulbuls, that placed Danainae thus relatively high, placed Pierinae generally quite unusually low. The transposition of these two groups constitutes the greatest divergence from normal tastes that I have come across, but, while the order I have indicated above is generally held to, small differences of taste, small transpositions of contiguous insects, occur as between any two species of birds, and, for that matter, any two individuals of the same species.

It is interesting to note how the experiments described in this paper bear on the above. Nauseation of *Irrisor* by Danainae and Acraeinae eaten beyond their respective safety-limits has already been referred to. The quaint shaking up again of a swallowed *Mylothris* in experiment 540

* There are probably few birds that are not specialists, and so indiscriminating in one direction or another. There would also seem to be a gradation between the more usual birds which in most things discriminate from the outset and those, like *Lophoceros*, which commence late.

by *Lophoceros melanoleucus*, and the same bird's attempted shaking up again of the yet higher-grade butterfly, *Neptis*, on another occasion, are probably to be explained on the same lines: each had been rashly eaten after its normal refusal-point had been passed. I have had numerous other instances of insects swallowed and brought up again at once, and it seems to me that many birds, at any rate, are often able to gauge an insect's effect directly it approaches the glandular stomach, perhaps through sensations arising from the stimulation and inhibition, respectively, of the digestive secretions*. In this last point we have, I believe, the whole explanation of the phenomena we have been considering. In my later and more knowledgeable experiments I found myself able to restore my animals' fading appetites, and to enable them to eat with impunity prey that they were already refusing, by giving them special dainties, and (in carnivorous animals) to spoil their appetites and make them refuse what they would otherwise have readily eaten by letting them see, smell, or taste the equivalents of *Acraea* and *Danaida* when they were by no means ravenous enough for them. It is probable, in other words, that certain insects, eaten eagerly to repletion-point, have the stimulative effect on a bird's digestive secretions that roast beef and certain soups have on our own, while others, such as the *Danainae*, tend definitely to inhibit the secretions, and can only be digested, or even retained, without discomfort when these are in great strength relatively to the amount of food contained in the stomach—when even the *Danainae* may stimulate them. It is impossible to go into the subject more fully here. Suffice it to add that just as the taste, smell, or even sight of certain foods that we can eat with impunity may in themselves, by unconscious association, be sufficient to promote a flow of the gastric secretions and give us thereby a feeling of appetite and eagerness, while the mere sight or smell of things that disagree with us produce a feeling of disinclination for them, so, too, with birds, choice probably becomes, with experience and practice, instinctive. A bird, seeing a well-known and lately experienced *Amauris* when not in a position to eat it with impunity, probably does not have to cast back in his memory for his previous experiences of it, or to calculate how full his stomach is. He merely feels disinclined for it.

One point, illustrated abundantly throughout the experiments on *L. leucomelas* (and in other experiments not described here), is worth mentioning again. It is that a rapidly-digesting bird is able to go on eating the most nauseous insects indefinitely, with frequent short intervals for subsidence, provided that no higher-grade insects are available to carry the filling of its stomach well beyond the point at which those nauseous insects are usually refused, and to keep it there.

The actual preferences shown in these experiments may be summarized as follows:—*Irrisor* preferred the Noctuid moth *Sphingomorpha* to the pleasantest Acridians and Locustids, and these to larval migratory

* Applied to frugivorous birds, this, with parental guidance, might explain sufficiently their learning to avoid poisonous fruits without being killed in the process. It is also no doubt perfectly true that fewer fruits are highly poisonous to birds than to us. The fact that birds are readily destroyed by powerful poisons concealed in foods in which they have learned to place perfect confidence is no objection.

locusts. The locusts were, in the first experiment, preferred to dead and dying butterflies, but the latter were far better relished in subsequent experiments in which they were offered alive. In fact there was an indication that a larval migratory locust was, at any rate, not *better* liked than *Byblia*—a butterfly as low-grade as *Neptis*. Amongst the butterflies themselves, *Hypolimnys*, *Hamanumida*, *Catopsilia*, the three *Papilios*—*dardanus*, *demodocus*, and *lyaeus*—the larva of *P. demodocus* and members of the genus *Precis* were probably preferred not only to the genera that caused nausea (*Danaida*, *Amauris*, and *Acraea*), but, with *Belenois*, to the moth *Olapa* and the butterflies *Mylothris*, *Terias*, and *Papilio angolanus*. *Lophoceros leucomelas* showed an apparent preference for a migratory locust and for *Precis cabrene* as against *Amauris albimaculata* and *A. ochlaea*, and for *Acraeinae* as against *Danainae*. The preference for *Danaida* as against *Amauris* was less certain, but very probable. Even *Danainae*, however, were probably liked far better—placed higher—than the brilliant moth-larva of experiment 520, and I thought at the time that greater repugnance was shown for the larvae of *Acraea terpsichore* than had been shown for adult *Acraeinae* and *Danainae*. If so, it would be only in line with my results from other birds. It was interesting that each bird could eat an *Amauris* or else an *Acraea* when it seemed to have had as much as it could safely eat of the other. This seemed to indicate that their protective qualities are very different. The difficulty experienced with *Catopsilia florella*'s stiff wings as against the pliable, easily-swallowed wings of *Danaida* was also interesting.

L. melanoleucus's preferences were ascertained a little more fully. I was now learning to experiment better, and had the advantage of dealing with a bird that was adult and full of experience and formed opinions when captured. The preferences seemed to be:—(1) *Pyrameis*, *Hamanumida*, *Melanitis*, and the skippers *Gegenes*, *Andronymus*, and *Parnara*; (2) *Padraona*, *Salamis*, *Papilio lyaeus*, and probably *Neptis*—with (1) and (2) would be bracketed *Precis* spp., *Catopsilia*, *Pseudacraea lucretia*, if recognized, and probably brown *Orenis* and *Leuceronia argia*, also the skippers *Baoris*, *Platylesches*, and *Rhopalocampta*; (3) *Ypthima* (probably); (4) *Belenois*; (5) *Mylothris*—with (4) and (5) might be bracketed *Terias* and *Leptosia*; (6) *Acraea acara*, *A. terpsichore*, and the two buff-patched *Amaurises*; (7) *Danaida chrysippus*; (8) *Amauris dominicanus*; (9) meat; (10) Cape gooseberries; (11) *Maba mualala* fruits. Read backwards, this list represents the order in which the objects comprising it would be discarded as the bird filled up from emptiness to repletion, or near it. Ten or eleven grades in all, and with further experimentation they would have been increased.

The Babbler's preferences, in so far as they were ascertained, stood in the following order:—(1) Termites; (2) *Pyrameis*; (3) *Neptis* and possibly *Henotesia*; (4) *Mycalesis campina*; *Ypthima*, and the pleasantest grasshoppers would come here or in (3), and *Hamanumida*, *Precis*, the ants, and the moth-larvae in or above that grade; (5) *Terias*; *Belenois* and the young green Saturniid larvae here or higher; (6) *Mylothris*; (7) *Aletis*, *Danaida*, and *Acraea*—with (6) and (7) would be bracketed the unpleasant gregarious moth-larvae and some of the Phytophagous beetles, and with (5), (6) and (7) the millipede, Arctiid larva, wasps, blister-beetles, and

pupal and imaginal ladybirds. The Babbler was more inclined to eat the latter, and especially their larvae, than any of the other birds, seeming to get rid of much of the juice, and with it, presumably, some of its objectionable qualities, by much rubbing. Vigorous rubbing was also used to exhaust the pungent but volatile defence of the millipede in experiment 564. The moth *Sphingomorpha* was much liked, *Osprynchotus* (the ichneumon) was placed high (an unusual occurrence), certain strong-smelling bugs were also placed high (by no means so unusual), *C. cloantha* was preferred to *C. florella* and *P. angolanus*, and the second-named butterfly probably to the third. The unusually high placing of the ants, the ichneumon, and the Coccinellid larvae suggest that *Crateropus* is perhaps a specialized bird, and that it would have been of great interest to pursue its general preferences further. The resemblance of its butterfly preferences to those of *Lophoceros melanoleucus* is marked.

The preferences we have dealt with so far are the *enforced* preferences of birds. These *have* to let pass an *Acraea* or a Coprid, let us say, because their digestion is insufficiently vigorous to deal with the former or their strength to break the latter. But there are two other kinds of preference—the choice of the largest, and the turning of the whole attention to the commonest, insect that they are at the time hungry enough for. Absorption in the search or watch for one particular kind of insect is, I believe, fairly frequent, and it probably pays the bird; it certainly accounts for a number of the instances of neglect we witness. And the selection of the largest insect present that the bird is hungry enough to eat—resulting, it may be, in the taking of an *Amauris dominicanus* in preference to the far higher-grade but smaller *Precis cebrenae*—is, as I have seen in both tame birds and wild, the rule where the bird *has* a choice and troubles to make it.

It is interesting to inquire how birds come to know that some insects may be eaten with impunity at a given moment and others not. Prof. Lloyd Morgan's experiments on young birds are well known. He found no indication that they possessed any inherited instinctive knowledge of what could and could not be eaten. I have myself carried out a similar series of experiments on some of our African birds—with the same result. Even the experiments I have described above contain some evidence bearing on the point, in the trial of a lump of earth and excrement by the Crowned Hornbill, its rejection after swallowing it of a *Mylothris*, in the actual nausea of the Wood-Hoopoes by insects that they had eaten, and, for that matter, in the continual rejections that took place after tasting (see, too, experiment 560). I have, in all my experiments, come across no evidence of visual instinctive recognition, but plenty of evidence to the contrary. Whether rejection by *taste* is equally non-instinctive is another matter. Watching a bird going through a long experiment, and noting the accuracy and relative lack of hesitation with which he pronounces his decision on insect after insect, by taste, one is almost convinced that the selection is instinctive. Yet, in view of one's experience with very young birds, and of such mistakes as those made by the Wood-Hoopoes and Crowned Hornbill, it is probably more correct to say that, with practice, recognition of deeper qualities by taste *becomes* instinctive, just as the playing of the piano does, only far more easily.

Two factors remain : parental education and personal experience. The latter is certainly by far the most important of the two, and we have seen in these experiments that birds readily profit by experience. But that parental influence is an important and long-lasting factor is suggested by the fact that so many young birds continue to go about with their parents almost up to the commencement of the next breeding-season, and by the most interesting attempt at dissuasion from eating a very low-grade insect by the older *Irrisor*. Here the young bird must have been nearly a year old. In this particular instance, the younger bird did not allow itself to be persuaded quite at once, but that birds do allow themselves to be influenced by the acceptances and rejections of others I have many time seen. It has happened with other birds, as it did with *Lophoceros* above, when two birds have been caged together, that one has gone so far as to offer an insect of which he was (one supposes) doubtful to the other while keeping a tight hold on it, and that he has swallowed it down himself if the other wanted it and thrown it away if it ignored it. I had for some time a hand-reared *Hirundo puella* caged with a captured *H. rustica*, and it was almost pathetic to see how the former watched the latter and relied on its acceptances and refusals.

The whole relations of old birds to young in the matter of food is a most interesting question for study. I have myself watched wild Bulbuls feeding their young, and I came to the conclusion that there the old birds captured what they were hungry enough for themselves. If the young bird refused the offering (as it sometimes did : so early does a knowledge of the qualities of prey and visual recognition of it commence) it was taken back and eaten by the old bird. Similarly, *Irrisor* A gave *Catopsilia* and locusts to C that he was hungry enough for himself, and took back and ate what C did not want. Yet he deprived C just afterwards of the greater dainty *Sphingomorpha* ! A gave C *Precis artaxia* and *natalensis* that he had been eagerly awaiting himself. But on C's holding the *P. natalensis* without eating it, A again seized it with apparent impatience at C's dallying, extracted it after a short struggle from her grip, and swallowed it himself, and ate the next two himself without troubling to offer them to her. The experiment continued to be interesting along the same lines. In the case of the second lot of Hoopoes, D and E, the relationship was probably not that of a parent and child, but matrimonial, and each gave to the other. The male, however, was the chief giver, and he was certainly a most generous and painstaking husband until his wife *snatched*. Then he gave her a most comical but effective lesson in discipline and manners.

It is impossible to carry out a long series of food-experiments without deciding that bird-language is really a very adequate instrument of communication, and that human beings talk too much. Nothing could have been clearer than the rebuke administered in experiment 518 and the fact that *Irrisor* E accepted it in a duly chastened spirit. Again, nothing could have been clearer and more unmistakable than A's actions in attempting to dissuade C from eating the *Danaida*, or than the actions of both birds in announcing to me their unwillingness to accept the last *Danaida*. Bill-wiping is a very wide-spread signal of dislike and refusal—not that it is used for this alone, for the bill often has to be merely cleaned.

The light closing of its tip on the object offered, followed by an immediate withdrawal, is also a common mode of refusal. My Owl (*Syrnium*), in refusing thus, would indulge in what I could only call 'apologetic nibbling', her bill sometimes not even closing on the object 'nibbled'. Turning the back is a last and most emphatic form of refusal, and used to be indulged in by my Roller. Anger was vividly expressed in experiment 520, probable request for information in other experiments, and gallantry to the opposite sex (or was it practical joking?) in 531. Eagerness has also its special signs—used, as I have seen, even by wild birds in soliciting prey captured by a companion—and so has disappointment. Even thanks was expressed in the bowing of the Hoopoes. Add the expressions of affection that are so frequently exchanged by birds, the actions of the male in courtship and of both sexes in the training of the young, the warnings against enemies and the threats and reminders to the same, and the signals by which birds keep in touch with one another, and we have a language that for all practical purposes is tolerably complete.

Behaviour in face of a snake—not that an *Amphisbaenid* is a snake!—the close study of the appearance of a rejected *Amauris* by *Irrisor*, and the deception of birds by resemblances in their prey, are, I think, almost the only remaining points to which I need call attention. The last point has been illustrated in numerous other experiments, and, taken together and in due relation to the fact that the same appearance is often brought about in unrelated prey by utterly different pigments, they suggest that birds see colours very much as we do. That some species are very blind, and others sharp-sighted, in relation to motionless objects (all depending on their general habits), I had, I think, little or no evidence in these experiments, but much in others. Both this fact and the above-mentioned study of the *Amauris* have an interesting bearing on the question of hypertely. Of the other senses of birds, smell only is worth referring to here. The ridiculously short tongue of *Lophoceros* and other hornbills, and the fact that they, nevertheless, base their acceptances and refusals on tastings performed with the very tip of the long bill, suggests that we have here a case analogous to smelling rather than true tasting. I have seen short-billed birds, on the other hand, bring the tips of their tongues into actual contact with the objects tested. That even these birds appreciate odours—though they do not, like mammals, use them for recognition—is shown by the behaviour of *Crateropus* in experiment 564 (a very extreme case, of course) and by the fact that my Swallows showed discomfort when strong-smelling insects (such as the moth *Xanthospilopteryx*) were brought at all close to them.

Discussion.—

Dr. RICHMOND WHEELER said that many points invited discussion had more time been available. The observations quoted by Professor Carpenter indicated that many kinds of butterflies were normally unharmed by birds, but that *Charaxes* species in South Africa were exceptional in this respect. But many, or most, of the attacks described in Swynnerton's important earlier papers (Proc. Roy. Ent. Soc. 1915, p. xxxii; Journ. Linn. Soc. Lond., Zool. xxxiii, p. 203, 1919; and III Internat. Ent. Kongr. Zürich, 1925) were made on *Charaxes* and other butterfly

species at rest, when upper-wing colours were usually invisible. Quotations in Cott's 'Adaptive Coloration in Animals' (1940) supported the view that healthy flying butterflies were usually safe from attack. Mutilated specimens came in a different category.

Dr. Wheeler urged that such questions should be considered on their merits, as far as possible without reference to *a priori* views. Professor Carpenter had spoken of the desirability of showing that flying butterflies were attacked by birds sufficiently frequently for natural selection to affect their upper-side coloration. But facts were more important than theories. There is danger of scientific orthodoxies being unduly stressed by their adherents, so that evidence in their favour is emphasized and evidence against them discounted.

Previous discussions by this Society have indicated that mortality was much greater in the early stages than among adult organisms, and that butterflies mostly die from physical causes, old age, or attacks by various predators when sessile and inert, with closed wings (Proc. Linn. Soc. Lond. Sess. 145, 16 Mar. 1933, pp. 97-105 : Sess. 151, 5 April 1939, pp. 79-88).

PROCEEDINGS OF THE GENERAL MEETING

13 November 1941

Dr. E. MARION DELF, Vice-President,
in the Chair

The Proceedings of the General Meeting held on Thursday, 30 October 1941, having been circulated, were taken as read and confirmed.

The thanks of the Society were recorded for a gift made since the last meeting :—from Mr. Oswald H. Latter.

Certificates of recommendation of the following candidates for Fellowship were read, for the second time, in favour of John Chear, Florence Annie Stanbury, Basil Derek Wragge Morley, Harold Cyril Bibby, Param Nath Bhaduri and William Springthorpe Lacey.

The Vice-President in the Chair reported the death of the following Fellow,—Sir Arthur W. Hill, K.C.M.G., F.R.S.

The following communications were read :—

On the occurrence in Hampshire of a spider of the family Argiopidae probably of foreign origin. By Mr. E. A. ROBINS, F.L.S. (Discussed by Sir Geoffrey Evans, C.I.E., Prof. F. E. Weiss, the Vice-President in the Chair and Dr. A. B. Hastings ; Mr. Robins replied.)

Abstract.—

In August 1940, Mrs. Marshall Bell, the Hon. Sec. of the local branch of the British Empire Naturalists' Association, told me that she had seen, in some waste land near Southbourne, a spider which had a body striped

black and yellow like a wasp. Knowing that there was no spider of this description in the British fauna, I concluded that she had made a mistake. In August 1941 she sent me a living specimen, and I at once recognized it as an alien.

It is comparable in all particulars with *Miranda aurantiu*, an Argiope spider of North America, and described in Comstock's 'Book of the Spider', which deals with the spiders of N. America. The abdomen is covered with yellow and black stripes and the cephalothorax is covered with long silvery hairs; the legs are also striped in bands; the body varies in size, but averages about 15 mm. to 18 mm. in length.

The colony near Southbourne is a large one, and appears to have been established for some time: how and when it originated we do not know, but I think that, if it is undisturbed, the spider may become part of the British fauna. The spider lives in loose grass near the ground, and the web, of geometrical form, has a zigzag ladder of silk across the vertical diameter, called a stablimentum. The cocoon is remarkable, about 15 to 18 mm. long, and pear-shaped, with an outer covering of a paper-like substance, brown in colour, and the neck of the pear filled with a thin membrane of white silk; this is to facilitate the emergence of the young spiders. The eggs are contained in an inner sac suspended from the neck of the cocoon, the space between the inner and outer cases being filled with loose reddish-brown silk, the first time that I have seen silk of this colour.

Owing to the late season I was unable to obtain any males; they had probably gone the way of most males, viz., eaten by the females.

It is exceptionally interesting that this foreign spider has been able to acclimatize itself in our climate, and the future of this colony will be studied with great interest.

Discussion.—

Sir GEOFFREY EVANS, C.I.E., asked if this spider is likely to become a nuisance, or in any way upset the balance of nature. Mr. Robins replied that in his opinion the activities of this spider may prove of benefit, since its prey consists solely of grasshoppers, and it may, therefore, help to keep them under control.

The VICE-PRESIDENT in the Chair paid tribute to the interesting contribution from Mr. Robins and to the excellent figures and specimens with which it was illustrated. She also recalled having seen on the open veldt near Johannesburg spiders attacking large grasshoppers (or grasshopper-like creatures, perhaps Cicadas) in both the ways described by Mr. Robins for the spider he kept in confinement.

'The position of the Caytoniales.' By Prof. T. M. HARRIS, F.L.S.
(Discussed by Prof. F. E. Weiss, The Lady Isabel Browne and the Vice-President in the Chair; Prof. Harris replied.)

Abstract.—

Professor T. M. HARRIS gave an account of the work published on the Caytoniales since Dr. Hamshaw Thomas's original paper. A leafy twig was described which was thought to indicate a tree or shrub rather than

to show herbaceous habit. The microsporophyll and synangium were described and contrasted with the stamen. The structure of the fruit was described and its pollination was discussed, particular stress being laid on the mouth of the fruit. Fruits of arrested development were mentioned, and a reconstruction was given of a possible ontogeny of the fruit.

The Caytoniales were held to be derivatives of the Pteridosperms, which were advanced in the small size of their leaves and sporophylls and in the incurving of the ultimate segments of the megasporophyll to give almost closed fruits. The differences between their organs and those of Angiosperms seem so great that such similarities as exist may be the result of convergent evolution. Nevertheless, the structure of the *Caytonia* fruit may still provide ideas about the ovary and pollination of the ancestors of the flowering plants.

Discussion.—

Professor F. E. WEISS expressed his appreciation of the very clear account Prof. Harris had given of the Caytoniales. Apparently Prof. Harris thought it was unfortunate for the understanding of the Caytoniales that their megasporangium should have been so frequently compared with the carpel of Angiosperms. They have been shown very definitely to be gymnospermic. Prof. Weiss was interested in the shedding of the leaflets from the petiole. He asked whether any case was known among recent or fossil ferns in which a leaf or leaflet was shed by the formation of an abscission layer.

The Lady ISABEL M. P. BROWNE asked Professor Harris whether in *Caytonia* the ovules were borne on the upper surface of the pinnule or expansion, which became bent over to form the fruit, as his sketch of the detached organ rather suggested, or whether these ovules were borne on the under-surface of the expansion.

The VICE-PRESIDENT in the Chair read a telephone message from Dr. Hamshaw Thomas (now Squadron-Leader), who had hoped to be present at the meeting but had been prevented at the last moment. She added that although we much regretted the absence of Dr. Thomas, who had founded the group and had introduced it to the Society in 1926, yet we were fortunate in having heard the account of the present position of the group from Prof. Harris, who had himself studied the Caytoniales for at least 10 or 12 years, and would doubtless be willing to answer any questions.

Mr. D'ALBINI BELLAIRS then gave an account of Jacobson's organ in snakes and lizards, in connection with his paper 'Observations on Jacobson's organ and its innervation in *Vipera berus*.' It will appear in the 'Journal of Anatomy', 1942.

PROCEEDINGS OF THE GENERAL MEETING
[in conjunction with the Zoological Society of London]
27 November 1941

Dr. E. S. RUSSELL, O.B.E., M.A., President,
in the Chair.

The Proceedings of the General Meeting held on Thursday, 13 November 1941, having been circulated, were taken as read and confirmed.

The President explained the reason why the present Meeting was a joint one with the Zoological Society of London, and welcomed the Fellows of that Society who were present.

The thanks of the Society were recorded for gifts made since the last meeting,—Mr. John Ardagh, A.L.S., Mr. D. J. Scourfield, I.S.O., and Prof. F. E. Weiss.

Certificates of recommendation of the following candidates for Fellowship were read, for the first time, in favour of Stella Ross-Craig (Mrs. J. R. Sealy), and William Glynn Burton.

The following candidates, whose names were read for the third time, were balloted for and elected Fellows :—John Chear, Florence Annie Stanbury, Basil Derek Wragge Morley, Harold Cyril Bibby, Param Nath Bhaduri and William Springthorpe Lacey.

The PRESIDENT called the attention of the Meeting to the Conference Memorandum no. 1 on 'Nature Preservation in Post-War Reconstruction' which was laid on the table, and thanked those Fellows who had sent in to the Society suggestions for the use of the Conference. These suggestions had been passed forward. The Secretaries had represented the Society at all the meetings and the Conference remains in being in the hope of further service.

The following communications were read :—

'A photographic record of the Linnaean Collections.' By Mr. J. R. NORMAN, F.L.S. (Discussed by the President, Dr. J. Ramsbottom, V.-P.L.S., Mr. S. Savage, Prof. F. E. Weiss and Mr. F. Martin-Duncan. (Printed in full, p. 50.)

'*Digitalis purpurea campanulata* (monstrosa).' By Mrs. MENIE WATT, F.L.S. (Read by Dr. B. Barnes, and also a letter from Mr. A. H. Hamm, A.L.S., who had sent a dried specimen from a garden in Oxford. Discussed by Prof. F. E. Weiss.) (Printed in full, p. 57.)

'White flowers in *Ranunculus Flammula* Linn.' By Dr. B. BARNES, F.L.S. (Discussed by Dr. J. Ramsbottom: Dr. Barnes replied.) [Printed in full, p. 58.]

Mr. R. H. BURNE, in the absence of the author, gave an account of 'The Mesorostral ossification of *Ziphius cavirostris*, by Dr. F. C. FRASER, F.L.S. This paper will be printed in the 'Proceedings of the Zoological Society,' 1942.

A PHOTOGRAPHIC RECORD OF THE LINNAEAN COLLECTIONS.

By J. R. NORMAN, V.-P.L.S.

It is quite unnecessary to-day to emphasize the supreme value of the Linnaean Collections of animals and plants, or of the annotated books and manuscripts relating to these collections. The specimens of plants, shells, insects, fishes, and other animals, including a high proportion of type material, must always be of fundamental importance to botanists and zoologists throughout the world, and The Linnean Society of London has rightly regarded these as a precious charge. Nor is it necessary to detail the history of these collections, or the manner in which they were acquired by the Society, since these matters have been fully dealt with by Dr. Daydon Jackson in his 'History of the Linnaean Collections' (1888), and more recently by Lt.-Col. A. T. Gage in his 'History of the Society' (1938).

In April 1939 the collections were removed for safety to Woburn Abbey, Bedfordshire, by the courtesy of His Grace the Duke of Bedford. With the advent of bombing raids in 1940 the Council set to work to devise a scheme for preserving a photographic record of the specimens, books and manuscripts, a scheme, however, which was dependent upon obtaining financial aid. The plan met with the approval of scientific men, and a generous grant of about £2,000 was made to the Society by the Carnegie Corporation of America for the purpose of preparing a 'photographic record of the collections and manuscripts of Carl Linnaeus' in the possession of the Society. Without delay, the Council appointed two small expert committees, one of zoologists and one of botanists, to advise them in the matter of the photography, and a joint meeting of these committees, under the chairmanship of Dr. Ramsbottom, was held in June 1941. Two possible methods of photography were discussed, the one involving photographs of quarter-plate size, the other photographs on 35-mm. micro-film. In the case of the first of these methods it was clear that the record obtained would have to be an incomplete one, and that only selected specimens could be photographed. Further, considerable time would be occupied, not only in making the exposures, developing the plates, making prints and so on, but also in the actual selection of the specimens, a task that could be undertaken only by experts in the groups concerned. It was estimated that, out of a total of more than 60,000 subjects, it would be possible to photograph only 29,400 for the sum of £2,000, and that the work would take about seven and a half years to complete. By the second method, although the

standard of the photography might be somewhat inferior, it would be possible to make a complete record of all the specimens, books and manuscripts in the space of about nine months. In addition, this would permit of a copy of the finished film being sent to the United States, and possibly others elsewhere. Since the whole scheme had been envisaged as a war measure, involving the minimum delay possible, the joint committees unanimously advised the Council to adopt the second or micro-film method, and, after estimates had been obtained from several firms, that of Messrs. Wallace Heaton, Ltd., was accepted, and they were instructed to start work at once.

By the kind permission of the Director and Trustees of the British Museum (Natural History) it was possible to transfer the collections from Woburn to the Zoological Museum at Tring, Hertfordshire, formerly the property of the late Lord Rothschild, and now a department of the Museum. The Council agreed that the photography should be carried out at Tring, and appointed a small supervisory committee consisting of the Assistant Secretary (Mr. S. Savage), Mr. J. E. Dandy, and myself. Early in July the collections were safely transferred under Mr. Savage's personal supervision, and in August Miss Gladys Brown was sent down by Wallace Heaton's to start photography. The work has continued steadily since that date, and by the middle of November all the specimens of animals and plants had been photographed to the satisfaction of the local committee, and some progress made with the annotated books.

As an indication of the magnitude of the task, it may be pointed out that the estimated number of exposures in the case of the plants was 14,000, for the insects 5,000, for the shells 2,000, for the fishes 158, and for the books and manuscripts 39,000—making a total of more than 60,000 exposures. As will be shown later, it has proved possible in practice to reduce these figures considerably by including more than one specimen in a photograph.

It was decided to start with the plants, and, as a preliminary, Mr. Savage spent some time at Tring in adding serial numbers to the herbarium sheets in accordance with Dr. Jackson's manuscript Catalogue. He also took this opportunity of going over the specimens and of making minor repairs where necessary. Miss Brown proved to be a skilful and competent photographer, and very careful in the handling of fragile specimens. With instructions as to the methods of dealing with the specimens, particularly with regard to the necessity for avoiding any bending of the sheets, the danger of placing them face downwards, the importance of keeping them in strict order both in the folders and in the brown-paper parcels, and so on, it was found that she could be left to proceed with the photography with comparatively little supervision. After being developed, the negative film was submitted to the members of the local committee for their approval as to the standard of the work, and this was also checked by Mr. Savage for possible omissions.

As a matter of scientific interest, it may be noted that in the course of her work Miss Brown was stung on the arm by one of the specimens of stinging nettle (*Urtica* sp.), almost certainly dried and mounted on the sheet nearly two hundred years ago. The arm showed a definite blister, apparently similar to that produced by a fresh specimen.

In the case of the insects, it was realized that the task of preparing them for the photographer would provide a much more complicated problem, and that the work should preferably be undertaken by somebody with a good knowledge of the group, as well as with experience in handling such delicate specimens. The Society is very greatly indebted to Mr. W. H. T. Tams, of the British Museum (Natural History), who kindly made arrangements to spend three or four months at Tring and to undertake the work. His extensive knowledge of photography proved invaluable, and it is certain that without his help it would have proved very difficult to obtain a satisfactory record of this group. Mr. Tams devoted many hours of the day and night to the work, week-days and Sundays alike, and succeeded in preparing all the 6,000 insects for photography in about ten weeks. For a part of the time the local committee also had the assistance and advice of Mr. A. S. Corbet, whose knowledge of the Rhopalocera proved very useful. I am indebted to both these gentlemen for much of the material included in these notes.

The collection of insects was formerly pinned into sixty glass-topped drawers, in what was described in a report to the Council, published in 1856, as 'a good and secure cabinet'. About 1929, Mr. A. G. Gabriel, of the British Museum (Natural History), was asked to undertake the delicate task of removing the specimens for greater safety to a series of glass-topped boxes, so designed as to fit into the same drawers. It is to be regretted that the opportunity was not taken to provide some photographic or other record of the arrangement of the specimens before they were transferred. Before beginning his own work, Mr. Tams's first action was to have a photograph made of each individual drawer, with the boxes *in situ*, and a series of enlarged prints made from these photographs provided him with a record of Mr. Gabriel's arrangement, and ensured that the specimens should be replaced in exactly the same disposition.

In considering the general policy to be adopted in preparing the insects for photography, it soon became obvious that, in order to avoid separating a particular specimen from its relevant label, it was essential that both label and specimen should appear in the same photograph, and to this end a scheme was worked out to provide for the largest possible photograph commensurate with retaining the label within the compass of the small 35-mm. frame. It was clear that, if the camera were to be placed sufficiently close to the specimen to provide a large and detailed picture, then only a portion of the label would appear in the photograph. To make a separate photograph of the label on a smaller scale would not only involve separating it from the specimen, but would also necessitate the constant raising and lowering of the camera. It was decided, therefore, to be content with a picture of smaller size, but one in which specimens and labels appeared in close association. A further advantage of this method lay in the fact that more than one insect (with its label) could be fitted into a single frame, and the total number of exposures consequently reduced. Five different sizes of frames were calculated, the smallest being four times the area of the 35-mm. frame of the film, and these were ruled off on sheets of white blotting-paper, which were in their turn pinned into insect store-boxes. Blotting paper was chosen because it was found that even a thin sheet of ordinary paper, in con-

junction with the sheet lining the store-box, was liable to turn the points of the pins. In this connection it may be noted that the pins used both by Linnaeus and Smith were of a heavy type, and sometimes nearly as thick as the specimens impaled upon them, a circumstance, however, which rendered the work of transfer much easier and the chance of mishap more remote.

Within each of the frames a small selection of insects of appropriate size was set out, with the labels (where these existed) in such proximity that there could be no doubt as to the relevance of specimen and label. The actual numbers of specimens in the various frames varied considerably, ranging from a single insect in the case of a large or rare species to more than a dozen in the case of small insects unprovided with data. A running number was added to each frame for purposes of checking the film, and another number indicating the box and drawer from which the specimen or specimens had been taken. Altogether more than 1,100 frames were prepared in this way.

During the course of this part of the work a certain amount of research proved necessary. For example, it was frequently found that odd specimens without labels had been placed at some considerable distance from the species to which they belonged, and in some cases the label was held down at one end by a pin bearing a specimen of a totally different species, presumably placed there to keep the label flat! By following the order given in the tenth and twelfth editions of the 'Systema Naturae', Mr. Tams has been able to check the arrangement of the specimens, as well as to straighten out some of the more obvious cases of misplacement, but, for various reasons, it was not possible to do this throughout.

If we consider the Lepidoptera as a representative group, we can get some idea of the general state of affairs and of the sort of research necessary in order to obtain an adequate photographic record. The number of specimens of this group in the collection before it left Sweden was stated to be 923; the present collection contains 3,344 specimens, of which 517 have name-labels in the handwriting of Linnaeus and 597 have no labels. Most of the remaining 2,230 specimens have been labelled by Smith, but it is evident that he attached name-labels to some of the Linnaean specimens which he doubtless found unlabelled. An interesting feature of the labelling was the almost complete absence of extra pin-holes in the centre of the label. This suggests that Smith, although he must often have added his own labels, took care that when he removed any one of the original Linnaean labels to insert the pin in the same hole when he put it back in the drawer. As further evidence that Smith was reluctant to change labels affixed by Linnaeus, the type specimen of *Pararge maera* Linn. bears a label 'Phippidus', in Linnaeus's handwriting, and also a second label, 'Maera nec Phippidus', in the writing of Smith.

Among the butterflies there are 107 specimens, believed to be types, which bear name-labels in Linnaeus's handwriting: there are 24 specimens, which are probably Linnaean types, without such labels. It appears that Linnaeus was less conscientious with regard to the labelling of the species described in his later works.

Of the 48 species of Rhopalocera described by Linnaeus from specimens stated to be in the Museum of Queen Ludovica Ulrica, and reported

missing therefrom by Aurivillius, who studied the Queen's collection at the end of last century, 31 have now been found in the Linnaean Collection. Taking the pinning and setting into account, it seems probable that many of these specimens were never in the Queen's collection.

The Linnaean Collection contains a number of type specimens of species described by later authors, among whom Fabricius is the most important. These specimens were certainly not in the Linnaean Collection when it left Sweden and must have been added by Smith. Some of the more miscellaneous material among the Rhopalocera in the collection is probably deserving of detailed study. One curious insect noted in this group was *Papilio eclipsis* Linn., an artefact, of which two specimens are included. These are actually examples of the Brimstone Butterfly (*Gonepteryx rhamni* (Linn.)), which have been treated with paint and ink to produce ocelli on the fore- and hind-wings. It is evident from the label that Smith recognized this 'species' to be a fake.

It is perhaps to be regretted that experts on the other orders of insects were not available to deal with their particular groups in the manner in which Mr. Corbet and Mr. Tams were able to deal with the Lepidoptera, and it is to be hoped that this will be possible at some future date. It may be mentioned that Mr. Tams has taken the opportunity to obtain a more detailed photographic record of the important specimens of Lepidoptera by making a series of special exposures on plates while these insects were set up for the photographer.

On the whole, the insects were found to be in very good condition, although some of the small beetles and bugs were so covered with mould that some degree of cleaning with a fine feather was necessary. An example of the difficulties encountered was provided by a specimen of the Crimson-speckled Footman (*Utetheisa pulchella*), which had been so badly damaged by a moth larva that the terminal part of the abdomen was hanging by a mere thread. This portion was removed and placed in a gelatine capsule before being mounted with the moth for the camera.

It is unnecessary to describe the actual photography in detail, but one or two special points may be mentioned. Trial exposures were made of certain frames, and the films developed in the Museum, before serious photography was attempted. These trials revealed the necessity for a change in the method of lighting, and reflected was substituted for direct light, with greatly improved results, especially in the matter of eliminating shadows. Photographing the different sizes of frames necessarily entailed changes in the height of the camera, and it was found convenient to expose all the frames of one size at the same time, without however, breaking up the natural orders of insects. Thus, for example, the whole of the Coleoptera were dealt with before passing on to the Lepidoptera. Mr. Tams was able to design a piece of apparatus by means of which it was possible to slide the store-boxes beneath the camera, and to bring the various frames into position without constant re-focusing. As in the case of the plants, the finished negatives were carefully examined and checked, and any frames which were considered unsuitable were re-photographed.

The shells were prepared for photography by myself, and the same sizes of frames were used as in the case of the insects. These were ruled

off on pieces of paper of neutral shade, which were pinned into shallow wooden drawers of the type normally used for the storage of bird-skins. Within each frame specimens of appropriate size were grouped, together with any labels found with them. There are very few Linnaean labels, however, as it appears that Linnaeus wrote the name of the species, together with a number, on the tin receptacles containing the shells. When Mr. Sylvanus Hanley was asked to go through the collection in 1856, in order to separate original Linnaean material from later Smithian additions, he found that many of the specimens had been displaced from their original receptacles. With regard to the boxes that still exist, it may be noted that corrosion of the metal has led to the almost complete obliteration of both name and number. Hanley succeeded in isolating the Linnaean specimens in a large number of genera, and these he affixed to wooden tablets and added a printed label bearing the Linnaean name. In the case of the remaining genera, the specimens remain in the original more or less chaotic state, usually without data (although many of the shells bear numbers), and it is clear that careful research by experts would be necessary to pick out the genuine Linnaean material. In the case of the genera *Trochus*, *Helix* and *Patella*, this appears to have been done in 1879 by Mr. E. A. Smith, who virtually carried on Hanley's work of isolation and labelled the species in his own handwriting. Finally, in 1912-13 Messrs. J. W. Taylor and W. D. Roebuck determined almost all the land and freshwater species, and these specimens have been isolated in a separate set of glass-topped boxes.

Where the shells had been mounted on tablets, the work of preparing them for the camera was comparatively easy, entailing little more than the temporary refixing with small pieces of plasticine of the many loose specimens, and the grouping of the tablets within frames of appropriate size. The shells not so mounted were grouped within the frames and then fixed in position with the same material, the labels or other data being pinned in close proximity. Care was taken to show more than one aspect of the shell in a particular species, provided that sufficient specimens were available. In the case of very small or fragile shells, a thin plate of plasticine was prepared and the specimens laid gently on this. Numbers were attached to each group of specimens, indicating the box and drawer (which were similarly numbered) from which they had been taken, and each frame given a serial number to facilitate checking.

I take this opportunity of expressing my thanks to Mr. A. E. Salisbury, who very kindly came over to Tring on two or three occasions to give me the benefit of his experience, both as a malacologist and as a photographer. He also helped greatly in examining and checking the finished negative.

The photography of the fishes presented little difficulty, the specimens consisting of half-skins pasted upon pieces of stiff paper, which could be treated in exactly the same way as the herbarium sheets. These had been numbered by me some years ago, in accordance with Dr. Günther's detailed catalogue of the specimens published in 1899. The remaining zoological specimens are almost entirely lacking in data, and consist mainly of dried crustacea and echinoderms: these were not photographed.

There is little to be said concerning the annotated books and manuscripts, as the preparation of photographic records of such material is a commonplace to-day. One point, however, seems worthy of note, and this concerns the difficulty of keeping a double-page opening flat and in constant focus, especially in the case of a stout bound volume. After some experiment, Mr. Tams has devised and constructed himself a simple but very effective piece of apparatus, which has proved highly satisfactory. By the simple manipulation of a handle, the photographer is able to release the book, turn over the page, and then bring the double opening into perfect focus again. The photographing of the books and manuscripts is now proceeding steadily, and it seems probable that the whole of the work will be completed well within the estimated period.

Discussion.—

The PRESIDENT said that the Society might congratulate itself on the successful way in which this difficult undertaking was being carried out. He had visited Tring and seen the work in progress, and he had been greatly impressed by the amount of labour put in by the local Subcommittee, and by Mr. Tams, whose expert assistance had been of very great service. He proposed a vote of thanks to these gentlemen, which was passed with acclamation.

Mr. S. SAVAGE said that now a complete photographic record of the Linnaean Herbarium was in existence, some form of catalogue would be needed as a guide, not only to the inscriptions, but to the genera, which latter are divided in the films by numbers only. Such a catalogue ought to be as brief as possible, but should enable anyone consulting the films to know at once the name Linnaeus gave to the plant and who wrote the inscriptions on the sheets and labels.

Unfortunately, Dr. Daydon Jackson's manuscript catalogue, drawn up during the last years of his life, is unsuitable both in form and matter, either for immediate printing or as a photographic record. Apart from many minor errors and omissions, it contains some more serious and extensive defects. For example, scattered throughout the Herbarium are many of Magnol's specimens, received from Professor de Sauvages of Montpellier, usually marked by Linnaeus with the letter 'M'. The labels are stated by Dr. Jackson to be in Magnol's handwriting, when they are obviously in that of de Sauvages. In a letter to Linnaeus dated 12 April 1747, de Sauvages, wrote [translation]:—

In that box are contained all the plants I have received from Monsieur Magnol, and you will distinguish these by their age; and, also, almost all which I [myself] have collected from time to time. Certainly you will be amazed that no plant has its name inscribed by Magnol himself or [is] supported by [his] labels. All were collected in bundles in books when my colleague, Monsieur Magnol, the son of the botanist, not at all acquainted with botanical matters, advised me to accept them; otherwise they would have been torn up and thrown away in the fire. At the same time he gave [me] some other plants glued to leaves of paper, but so worn away as to [make it] impossible to recognize them, and they may be of no use. You, most renowned man, will have looked for a rare, neat herbarium, worthy of Magnol; behold only plants so obsolete and

old that I greatly fear they may stir [in you] a dislike for more Magnoliana: but those of my own providing are more recent—would that they may please you!’

There are other instances of incorrect attribution of handwritings in Dr. Jackson's catalogue.

Perhaps one of the most striking pieces of Dr. Jackson's research on the Herbarium was his rediscovery of the meaning of some of the signs used by Linnaeus. Dr. Jackson reached his results by collation and deduction and gave his latest interpretation of these signs in the Supplement to the 'Proceedings,' 134th Sess., 1921–22. Since then Dr. Erik Hulten, in his 'Flora of Kamtchateka', 1930, showed good reasons for his opinion that signs nos. 1–4 were intended by Linnaeus to denote geographical areas and not persons, as proposed by Dr. Jackson. Sign no. 1 indicates a plant from the western edge of Asia: no. 2, eastern Asia: no. 3, Kamtchatka: no. 4, central part of Asia. Mr. Savage suggested that sign no. 12, found on the rice-paper sheets of Bladh's plants, is also a geographical sign, and indicates China.

In his recent examination of the Herbarium, Mr. Savage found a note by Sir James E. Smith, on the sheet of *Sonchus tataricus* stating that a similar specimen, named by the elder Linnaeus, had been given to Sir Joseph Banks. As the specimen in Herb. Linn. is named and dated 1778 by the younger Linnaeus, it is possible that the Linnaean type-specimen of this species may be found in the Banksian Herbarium.

Mr. F. MARTIN DUNCAN said that he would like to congratulate Mr. Norman, and the Society, on the successful completion of a very valuable and important piece of work accomplished under the existing difficult conditions. He had felt some concern when he heard that the 'micro-film' process had been adopted throughout for photographing the Linnaean Collection because the amount of reduction in the size of the image entailed must inevitably affect the already microscopically small but specifically important markings on some of the Micro-Lepidoptera and minute Coleoptera in the Collection. However, they had just heard from Mr. Norman how the Society had been able to enlist the enthusiastic interest and valuable assistance of Mr. Tams in the grouping and lighting of the specimens, and that meant, as the examples exhibited fully demonstrated, that the best possible results had been obtained.

DIGITALIS PURPUREA CAMPANULATA (MONSTROSA)

By MRS. MENIE WATT, F.L.S.

I am particularly interested in the account in our 'Proceedings' of 19 June last, relating to the *Digitalis purpurea* with the cup-shaped flower on top of the spike.

I first saw this variety in the flower-troughs which decorated the corridors, etc., in the Casino at Vichy, whither I accompanied my husband for a number of years, after his doctor prescribed for him the 'cure' at Vichy. As we both like foxgloves, I got in touch with the town gardener

at Vichy, and shocked him by suggesting that this (to me) unusual foxglove was a monstrosity. Yet he kindly gave me a catalogue of Rivoire, père et fils, 16 rue d'Algérie, Lyon, where the plant was listed as 'Digitale à fleur Campanulée. *Digitalis purpurea campanulata* (monstrosa)'. It was still in their catalogue about ten years afterwards—1934, p. 75.

Though we have moved house since we were able to grow this foxglove in quantity, we have never been without it until last year when, as a result of previous 'tidying' of the rhododendron bed, where it was established, a jobbing gardener destroyed quantities of mixed seedlings without having noted their origin.

The phenomenon of pelorism in *Digitalis purpurea* was first described, I believe, by Professor Vrolik of Amsterdam in his paper 'Ueber einer sonderbaren Wucherung der Blumen bei *Digitalis purpurea*,' published in 'Flora' (xxviii, p. 1 : 1844). Since this time not only have there been numerous references to it in horticultural literature—the 'Gardeners' Chronicle' and in 'The Garden', for instance—but several books of botanical importance give it prominence. Penzig and De Vries both give good accounts of it, the former in his 'Pflanzenaterologie', II, p. 208 of 1894, and again in his second edition in 1922, the latter in his 'Mutationstheorie' (I, p. 567 : 1901) and in his 'Species and Varieties, their origin by Mutation' (p. 483 : 1906). Hoffmann, in his paper 'Culturversuche über Variation' (Bot. Zeit. XLV, pp. 71–76 : 1887), states that pelorism is inherited, and on this subject, Keeble, Pellew and Jones have an interesting paper in the 'New Phytologist' (ix, p. 68 : 1910). They conclude that

- (1) Peloria in foxgloves is a Mendelian recessive to normal,
- (2) Peloric flowers and non-peloric flowers of peloric plants carry the recessive character.

It is perhaps of interest to record that at Achnacarry, in Inverness-shire, in 1937, several plants, apparently wild, were growing on the fringe of a natural oak and beech copse.

Personally, I do not think that this interesting variation is so decorative as the ordinary foxglove. In my experience, the cup-shaped bloom on the top of the spike always comes into flower before the other flowers of the spike, and withers long before the spike has finished flowering, thus giving the plant a shabby look throughout its blooming. But that this is not constant is shown by the photograph, pl. xxxiv, in vol. II of Worsdell's 'Principles of Plant Teratology' (1916). Here the peloric flower is in full bloom, whilst the normal flowers just below it are past, the corollas having fallen off.

WHITE FLOWERS IN *RANUNCULUS FLAMMULA* LINN.

By B. BARNES, D.Sc., Ph.D., F.L.S.

White specks and patches are common enough on old petals of yellow-flowered species of *Ranunculus*, and old flowers may sometimes be found which are almost wholly white, but in such flowers it is easy to see that the stamens have moved outwards and dehisced, and that the carpels

are swelling. The white flowers to be considered here were young, the whitening being often well developed before any great change had occurred in the stamens. Moreover, the petals were really white, and not pale yellow or cream, the condition which seems to have characterized most of the so-called white-flowered sports of *Ranunculus* mentioned by various writers on the genus.

Early in September 1927 a plant of *Ranunculus Flammula* was found in a wet hollow at Fernhurst, Sussex. It bore two flowers, both with pure white, opaque, glossy petals. The flowers were fresh and young, with most of their stamens closely packed and with intact anthers. This was the only white-flowered plant among hundreds of the normal yellow-flowered form. It had a dozen strong stems, mostly ending in groups of developing achenes, together with a few unopened buds. Just before I returned to London, three of the stems were cut off at ground level, and these rooted easily in damp soil in my garden. Each soon put up strong basal shoots, and next year the three plants flowered well: all the flowers were white. A number of yellow-flowered plants were raised in the same way at the same time, and until they flowered there was nothing to distinguish the two lots of plants; neither then nor subsequently was there any reason to suppose that the white-flowered plants were diseased or lacking in vigour.

Between 1927 and 1933 the stock of white-flowered plants was increased by means of cuttings to more than two dozen; they were kept out of doors throughout the years. During the same period the original plant was visited several times each year; it remained healthy, but it did not spread, nor did any similar plants develop in its vicinity. In the summer of 1933 some of the white-flowered plants from my stock were taken to the Chelsea Physic Garden, and others were handed to Dr. Turrill, who had them planted at Kew. At the same time herbarium specimens were supplied to the Natural History Museum and to the Kew Herbarium. In the autumn of 1933, in addition to the original plant at Fernhurst, there were living plants of the white-flowered form in the Physic Garden, at Kew, and in my garden in SE. London.

I had intended, when time allowed, to investigate the structure of the petals of the flowers, and also to look into the genetics of the plant, but as I was busy with other things at the time, and as the plants grew so well, there seemed no urgency to get on with that work. Achenes were not collected, and no special precautions were taken to get the plants through the winter of 1933-4; they had already survived several winters in cultivation, and no trouble was expected. In February 1934, however, my white-flowered plants were in a bad state, and they died soon afterwards; so did the plants in the Physic Garden, and as those at Kew could not be found, they too must have died out. To complete the catastrophe, the original plant could not be found at Fernhurst, so that my hopes of renewing the stock were disappointed. It too disappeared during the winter of 1933-4, and no white-flowered plant reappeared there up to the time of my last visit in 1939.

The wild plant may be presumed to have arisen from a seed; the rest of the stock came from cuttings from it or from cuttings from plants grown from the first cuttings taken. It does not seem unreasonable to

regard the whole stock of white-flowered plants as making up one individual, even if that individual was separated in four distinct places. The winter of 1933-4 was not a hard winter, and it had no seriously damaging effect on yellow-flowered plants of *Ranunculus Flammula*. My yellow-flowered plants survived the winter, and some wild populations which had been watched for several years seemed to be as dense as ever in the summer of 1934. It is possible that there was some weather condition that winter which bore hardly on the white-flowered stock, but it is not easy to see how that supposed condition could act so evenly in four separate and different places. It is tempting to venture a guess that the white-flowered stock died out that winter simply because the individual which it represented had come to the term of its natural life, but there is no real foundation for such a guess.

Little, if anything, seems to be known of the expectation of life of a herbaceous perennial, and maybe a herbaceous perennial has no definite expectation of life. Seifriz (1920) collected information which suggests that some of the bamboos have a life-cycle of determinate length, but those bamboos behave differently from the lesser spearwort. They vegetate for a number of years, then flower and die, but the spearwort flowers every year, and makes provision for the next year by the production of basal shoots.

The discovery of the white-flowered plant suggested that it would be well to look for similar plants elsewhere, and to look also for evidence of at least partial whitening in young flowers. With a little practice

Ranunculus Flammula.

Date.	Locality.	Numbers of flowers.			
		Normal.	Old.		White.
			White-spotted petals.	Yellow petals, some falling.	
9. 7. 31	Fernhurst, Sussex.....	156*	29	—	6*†
28. 7. 31	Brightlingsea, Essex.....	404*	2	2	—
30. 8. 31	Lac Estivadoux, Auvergne.....	237*	47	—	—
4. 9. 32	Lake Gormire, Yorkshire.....	722†	39	—	—
15. 9. 32	Linchmere, Sussex.....	1000†	27	—	—
15. 9. 32	Fernhurst, Sussex.....	1647	128	18	3*†

* Old flowers with all stamens moved outwards.

† Flowers with about half the stamens moved, and, therefore, old enough to show bleaching.

* † The original white-flowered plant.

it was soon possible to look quickly over large populations and, by observing the stamens, to pick out flowers which were of suitable age to show early whitening, if any tendency towards that condition was present. Surveys were made in a number of places; they failed to reveal any indication of the tendency, but a few samples of the kind of results obtained may be of interest; they appear in the table on p. 60.

The white-flowered form was thus found only in the one spot.

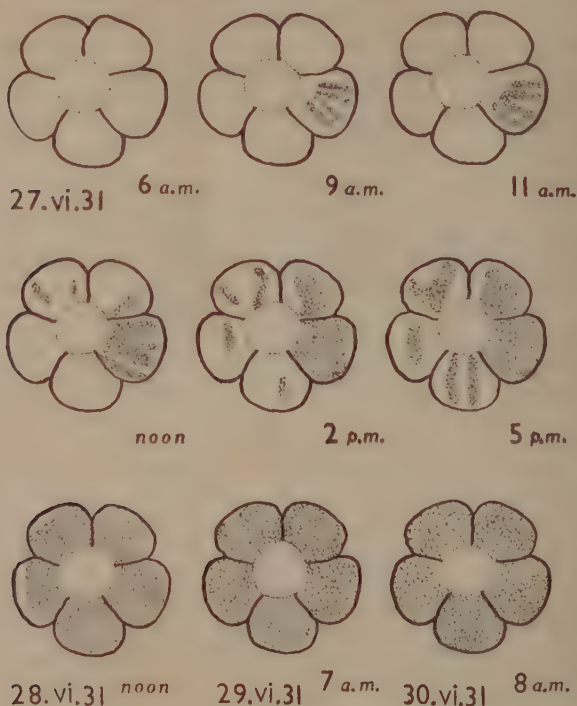
Our Fellow, Mr. J. Parkin, whose work on the glossy petal of *Ranunculus* is well known, has informed me in a letter that in his prolonged observations on species of *Ranunculus* he has never seen a white sport of *R. Flammula*.

Often, but not always, a flower-bud of *Ranunculus Flammula* begins to loosen in the evening, continues to open very slowly during the night, and expands rather quickly next morning. If a large bud from a white-flowered plant is pulled to pieces just before the petals start to separate, the petals are yellow, as are those of a freshly opened flower. In ordinary fine summer weather, however, small white patches soon appear on one of the petals of a flower which opened in the early morning, and by the evening of the first day most of the yellow has been replaced by white; the tips of the petals are the last to whiten, and the completion of the change may need some two days. A number of flowers were observed over the whole period needed for the colour change to occur, and the course of events in one of these flowers is represented diagrammatically in the figure on p. 62.

Sometimes, but not always, the white patches form in longitudinal streaks, following the veins of the petal. Whitening is always complete before the flower is old, and the white flowers, like the yellow flowers, last six or seven days. The change in colour goes on rather faster than the changes in the stamens which accompany it. In the flower represented in the diagrams, few stamens moved during the first day; by noon on the second day most had moved outwards and about half had dehisced, but movement and dehiscence were not completed until the evening of the fourth day.

The change in colour is due to bleaching of the pigment dissolved in the oil in the upper epidermal cells; according to Köstlin (1924) the pigment is carotin. A few white and yellow flowers of the same age were preserved, and from these some sections have been cut. The sections do not show any noticeable difference in the structure of the two kinds of petals, but there are several places in the sections made from white petals where the upper epidermis has come away from the underlying starch layer, while separation of this sort has not been seen in sections of yellow petals. The two kinds of flowers were gathered at the same time, treated with the same fluids, embedded in one block of paraffin and cut together. That being so, it seems unlikely that the separation of the epidermis in white petals is merely an artefact, but until I can get more material and check the point thoroughly, I hesitate to contradict the statement made by Köstlin (1924), that separation of the epidermis does not occur when white spots appear in old petals of yellow-flowered species of *Ranunculus*. I cannot, however, accept his view that wet weather favours bleaching. In sunny weather my plants gave results

such as have just been described, but in wet weather flowers may show hardly any whitening even after they have been fully open for a couple of days, though they whiten completely in four to five days.



Diagrams showing the spreading of white patches (indicated by dotting) in petals of the same flower of *Ranunculus Flammula* on the days and at the times stated.

It would have been interesting to have undertaken a study of white and yellow petals in relation to the separation of the epidermis comparable with that of Tetley (1932) on healthy and silvered leaves of the Victoria plum, but the death of the stock prevented that, as it has prevented the clearing up of a number of other interesting problems raised by this white-flowered sport of *Ranunculus Flammula*.

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[Part 1, pp. 1-62, *published* 6 November 1942.]

